Issued April 20, 1916.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION, THOMAS F. HUNT, DIRECTOR; CHARLES F. SHAW, IN CHARGE SOIL SURVEY.

SOIL SURVEY OF THE MERCED AREA, CALIFORNIA.

BY

E. B. WATSON AND PARTY.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1914.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1916.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Soils,
Washington, D. C., September 7, 1915.

Sir: During the field season of 1914 a soil survey was made of the Merced area, California. This work was done in cooperation with the University of California Agricultural Experiment Station, and the selection of the area was made after conference with State officials. Mr. E. B. Watson had charge of the work in the field and was assisted by Messrs. E. C. Eckmann and L. C. Holmes, of the United States Department of Agriculture, and Messrs. J. W. Nelson, J. E. Guernsey, and C. J. Zinn, of the University of California.

I have the honor to transmit herewith the manuscript report and map covering this area and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1914, as provided by law.

Respectfully,

Milton Whitney,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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SOIL SURVEY OF THE MERCED AREA, CALIFORNIA.

By E. B. WATSON and Party.

DESCRIPTION OF THE AREA.

The Merced area includes all of Merced County lying northeast of the San Joaquin River, except a small part lying west of Range 12, which was included in the survey of the Modesto-Turlock area. It is situated nearly midway between the northern and southern ends of the great San Joaquin Valley of California. On the north it is bordered by Stanislaus County, on the east by Mariposa County, on the south by Madera County, and on the west by the San Joaquin and Merced Rivers. It comprises 960 square miles, or 614,400 acres, being nearly as large as the State of Rhode Island.

The area extends from the edge of the foothills bordering the Sierra Nevada Mountains westward a distance of 25 to 35 miles to the San Joaquin River. It therefore embraces all gradations of topography from the foothills proper to the flat land in the trough of the valley.

FIG. 1.—Sketch map showing location of the Merced area, California.

On the eastern edge there are a few small areas of true foothills, with elevations of 500 to 1,000 feet above sea level. These are steep hills with rock outcrops, mapped as Rough stony land. Just west of these is an extensive lower lying belt consisting in part of rounded hills, many of them covered with cobblestones, and in part of rough, broken hills. In the northern part of the survey this belt is wider and the hills relatively higher than toward the southern part, where it narrows and the elevation is lower. To the west of this belt of rolling hills and at a considerably lower level is a wide belt of comparatively level land, which has been built up by the more recent alluvial-fan deposits of the streams issuing from the mountains and foothills. On this plain considerable agricultural development has taken place. The alluvial fan of the Merced River, in the northern part of the area, reaches nearly to the San Joaquin River. The fans of the smaller streams south of the Merced reach only two-thirds of the way to the valley trough as noticeable fans of coarse material

with a marked slope, although their broad, flat distal ends of finer grained material extend to the San Joaquin River flats.

In the trough of the valley bordering the San Joaquin River there is a level, poorly drained strip from 4 to 8 miles wide which is traversed by numerous old sloughs or drainage channels. As the Merced River is reached, however, the poorly drained portion becomes very narrow, since the fan of that stream extends nearly to the San Joaquin River. Across the northern part of the area the Merced River, a perennial stream, fed from the snows of the high Sierras, has cut its present valley about 200 feet deep in the hill belt along the border of the valley, and has developed a flood plain 3 to 4 miles wide. This narrows downstream, however, until it merges with a small fan that the river is now building, with its apex a few miles above the river's mouth, where the valley trough fades out into the greater San Joaquin Valley trough. Bear Creek, Mariposa Creek, and Chowchilla River, all intermittent streams, cut through the rolling belt south of the Merced River and are lost in distributaries on their fans in the lower part of the valley.

The Merced area, as well as the remainder of the San Joaquin Valley, was settled much later than the coast sections of California. The first white men in this region were hunters and trappers who came in 1823, but prior to 1848 there was no permanent settlement of which there is record.

Permanent settlement began in 1849 and 1850, when gold was discovered. Gold was not found within the area, but was found in Mariposa County, adjoining it on the east. Unsuccessful gold seekers very early began to settle along the route of travel in the area, on the bottoms of the Merced River, along Mariposa Creek, and along the road skirting the foothills, known as the Millerton Road, which later became the eastern boundary of the county.

The population increased quite rapidly after the first settlement. The area was at first a part of Mariposa County. By 1855, when Merced County was established from Mariposa County, the population numbered about 1,000. The first settlers came almost entirely from other parts of the United States. They developed the large ranches, so characteristic of the valley in the early days and still found in some sections. Later many immigrants, mainly Portuguese and Italians, came into the county. The increase in population during the last 10 years seems to consist largely of people from the countries of southern Europe. There are few Mexicans, Chinese, and negroes in the area.

The stock-ranch country, or the strongly alkali land along the San Joaquin River and the rolling hills in the eastern part of the county, is very sparsely populated. The cattle ranches are owned largely by nonresidents and the improvements are mostly insignificant. The

grain ranches, found mainly in the northern and eastern parts of the area, are smaller, and these sections are more thickly populated than the area occupied by cattle ranches. The densest population is on the sandy lands near Atwater and Livingston, where the holdings are small, ranging from 20 to 40 acres.

Merced has been the county seat since the town was established in 1872. It is the principal town of the county, and in 1910, according to the census, had a population of 3,102.

Snelling, on the Merced River, was the first town organized in the county and was the county seat from 1855 until 1872. It has now about 150 inhabitants. Merced Falls, located on the Merced River where it emerges from its gorge in the foothills, has about the same population. At one time it was a place of considerable importance, having a flour mill, foundry, and woolen mill. Its principal industry now is timber sawing. Both Merced Falls and Snelling are on the Yosemite Valley Railroad. Hopeton, located 6 miles west of Snelling, is one of the oldest villages in the area. It now has only half a dozen houses. Atwater and Livingston, with populations of 300 and 250, respectively, are thriving towns on the Southern Pacific Railroad west of Merced and the centers of the fruit and truck industries of the area. Winton, Cressey, and Planada are new towns on the Atchison, Topeka & Santa Fe Railroad. Le Grand is a town of about 350 inhabitants in the southeastern part of the area on the same line. It is the center of a large grain-growing district. Athlone is a shipping point on the main line of the Southern Pacific Railroad, and Amsterdam, Arundel, and Ryer are shipping points on the Oakdale branch of that system.

The Merced area is well supplied with transportation facilities. The main lines of both the Southern Pacific and the Atchison, Topeka & Santa Fe Railroads traverse it, connecting Stockton, Sacramento, and the Bay cities on the north with the principal cities of southern California on the south and, through these cities, with the markets of the East. The Oakdale branch of the Southern Pacific runs northwest from Merced, and the Yosemite Valley Railroad extends from Merced north to the bottoms of the Merced River and thence up the Yosemite Valley, 80 miles east of Merced. The surplus agricultural products are shipped to the larger cities of California and to the markets of the East.

The roads in the area are for the most part level and well cared for. On the Madera and Fresno sands they become dry and heavy during the summer, but many of the more traveled roads in this part of the area are kept in good condition by oiling. The unsurfaced roads on the heavy Madera and Fresno soils are very muddy and heavy during the rainy season, but the main roads here are surfaced with crushed

rock. One branch of the State highway crosses the area, paralleling the Southern Pacific Railroad.

CLIMATE.

The climate of the Merced area is semiarid. There are two distinct seasons, the wet and the dry, differing not only in precipitation, but also in temperature, humidity, and number of clear days. These two seasons coincide with the winter and summer.

The following table shows the mean monthly and the mean and extreme annual precipitation for three stations located within the area, and for Los Banos, on the west side of the San Joaquin in the trough of the valley:

Precipitation in Merced County ending with the season of 1911–12.

Station.	Elevation.	Years.	Month.												Annual mean.	Wettest year.	Driest year.
			July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.			
	Ft.																
Merced....	173	40	0.01	0.02	0.21	0.49	1.17	1.53	2.35	1.48	1.80	0.95	0.54	0.12	10.82	22.08	3.20
Le Grand...	255	13	.01	T.	.20	.91	1.34	1.51	2.62	1.85	2.72	.89	.52	T.	12.57	20.07	4.87
Merced Falls	351	6	0	0	.20	.65	.83	1.52	5.14	1.75	3.15	.99	.50	.12	14.95	20.58	10.08
Los Banos..	121	39	.01	.01	.13	.33	.97	1.30	1.77	1.11	1.40	.57	.85	.07	8.52	14.41	1.60

The rainfall is least in the trough of the San Joaquin Valley, the annual mean at Los Banos being 8.52 inches, and increases as the foothills are approached, averaging 14.95 inches at Merced Falls. As the latter station record has been kept for only 6 years, and during a period of comparatively heavy rainfall, the figures probably exceed the normal amount of precipitation there.

The almost entire lack of rainfall in the summer months permits the use of large and efficient harvesting machinery in grain farming, and makes the curing of raisins possible. January and March are the months of greatest rainfall. There are great seasonal as well as annual variations. The rainy years are the years of greatest prosperity. The pasturage is abundant and the grain yields are good. During years in which the rainfall drops much below the average the grass is scant and all dry-farmed crops suffer.

The rains seldom continue longer than three or four days at a time, but in unusually wet seasons they may last for a week or more. The precipitation is well distributed through the winter months, and generally occurs as gentle showers or in rainy periods interspersed with either clear or foggy weather, enabling the soil to become saturated to a considerable depth where subsoil conditions are favorable. Violent thunderstorms, hail, and cloudbursts are unusual.

The following table gives the highest, lowest, mean maximum, mean minimum, and annual mean temperatures at Merced and Le Grand, and the average number of rainy days and the dates of latest killing frost in spring and earliest in autumn at Merced:

Temperature at Merced and Le Grand, and average number of rainy days and absolute and average dates of latest killing frost in spring and earliest in autumn at Merced.

Station.	Temperature.					Average number rainy days.	Latest killing frost in spring.	Earliest killing frost in autumn.	Average latest killing frost in spring.	Average earliest killing frost in autumn.
	Highest.	Lowest.	Mean maximum.[1]	Mean minimum.[1]	Annual mean.[1]					
	°F.	°F.	°F.	°F.	°F.					
Merced	116	16	76.4	45.8	63.2	40	Apr. 13	Nov. 13	Apr. 7	Dec. 3
Le Grand	117	20	74.8	46.3	60.9	.....	.....	.....	.....	.....

[1] Figures for maximum and minimum temperatures at Merced represent the mean for an 11-year period; for annual mean, 38-year period.

The temperature at Merced ranges from 16° F. to 116° F., the annual mean being 63.2° F. July and August are the hottest months, but temperatures above 100° may occur from May until October. During this time, however, the relative humidity is low and the heat is not so oppressive as it would be in more humid climates.

Frosts are of frequent occurrence during the winter months, but only occasionally are they heavy enough to do severe damage. It is recognized, however, that they are too heavy at Merced and in the lower parts of the area to make the growing of citrus fruits a safe venture. The average date of latest killing frost in spring at Merced is April 7, and of the earliest in fall, December 3. Hardy vegetables, such as lettuce, turnips, radishes, onions, cabbage, cauliflower, and many other truck crops, are not affected by freezes during the winter months. Roses bloom outside during the entire winter.

During the dry season the humidity is very low, but during the winter season it is quite high and fogs are of frequent occurrence. These usually occur in the morning and disappear before noon. The prevailing winds are from the northwest, and there are many windy days during the year. South or southeast winds usually bring rain. Occasional very strong winds occur, usually from the northwest, which carry dust and do considerable damage. If this wind occurs before grain on the light soils has made a good growth the grain may be blown out and the crop lost. These winds have caused much drifting of the lighter, sandy soils of the area since cultivation has been begun.

AGRICULTURE.

The early settlers in the Merced area gave their attention mainly to cattle raising. Records show that alfalfa was sown as early as 1854 and that orchards and vineyards were set out in 1855 along the Merced River. Barley was the favorite grain crop during the fifties, owing to the demand for feed by freighters and stock raisers, but by 1860 there was nearly as much wheat grown as barley, and soon after that year wheat became the leading crop. There was a very disastrous drought from 1862 to 1864, when crops failed over vast areas, cattle died of starvation, and heavy losses resulted in the San Joaquin Valley. The stock losses gave a great impulse to grain growing, especially wheat, but in spite of the losses the census of 1870 shows nearly twice as many cattle in Merced County as were enumerated in 1860. Nevertheless, by 1867 grain growing had begun to encroach on the cattle ranges, and fencing laws curtailed the profits of the cattlemen. In 1870–1872 the Southern Pacific Railroad was built through the valley, causing a great expansion of grain growing. The droughts in 1870–71 and 1876 77 were more disastrous to the cattlemen than to the grain growers, and by 1880 the number of cattle in the Merced area was less than in 1860.

The quantity of wheat grown steadily increased and that of barley decreased. An added impulse was given by the introduction, about 1880, of the combined harvester and thrasher, as well as the discovery that the rolling valley borderlands, heretofore considered of no value except for pasture, would produce good crops of grain. The decade from 1880 to 1890 was the period during which the extensive grain farms flourished. According to the census reports, nearly ten times as much wheat was grown in Merced County in 1890 as in 1880. Since that time wheat growing has been on the decline and barley has been taking its place, until now there is comparatively little wheat grown. During the last 20 years the profits in grain growing have been decreasing, both because of lower yields and of higher cost of production.

Cotton was first grown in the area in 1865, and it was thought at one time that it would be an important crop. It was confined to the Merced River bottoms. In 1871 one farmer obtained a bale per acre from 51 acres. He received 6 cents a pound for the seed cotton and found the crop very profitable. The industry continued with varying degrees of success until 1881, but died out soon after this time.

Another stage in the development of the agriculture of the area began about 1890. Prior to that time irrigation for crops and fruit had been confined to the alluvial soils along the Merced River, and several small ditches had been constructed. In 1888 the large canal which takes water from the Merced River not far below Merced

Falls and conducts it around the ridge of high land to the level country to the south was completed. The Stevinson ditch, which takes water from the San Joaquin River and irrigates land in the western part of the area around Stevinson, was completed in 1889.

Up to that time land holdings had been large, owing to the course the agricultural development of the area had taken. The farming was of two types. There were the cattle ranches, very large, and the grain ranches, not so large as the cattle ranches, but averaging about 1,000 acres in size. Small farmers could not compete with the large farmers on account of the economic advantage that large machinery gave to the latter, and the number of small farms was negligible. The profits from the large ranches were so great that owners generally lived in the cities, leaving the care of the cattle or the management of the grain growing to foremen. Some farmers carried on both cattle and grain raising.

In 1890 development of the small irrigated farms, with intensive cultivation, was begun. The three types of farming are still followed. Nearly half the area is probably best suited for grazing land for cattle and sheep, and the stock ranch apparently has a permanent place in the agriculture. With the development of the irrigation systems by the building of storage reservoirs and the sinking of wells, and with the cultivation of new crops and the adoption of new systems of farm management, the area devoted to grain farming will be encroached upon, until in time it may be entirely used for irrigated crops. This will mean an increase in the number of farms intensively cultivated. This tendency toward the development of smaller farms involves the actual settling of the land and the cultivation of the farms by the owners.

The following table, for Merced County as a whole, shows the number and average size of farms and the average improved acreage per farm, and gives a fair idea of conditions in the area surveyed:

	1890	1900	1910
Number of farms	798.0	999.0	1,856.0
Average size of farms.....acres..	1,101.0	1,668.6	626.2
Average number of improved acres per farm	785.0	614.0	327.4

The number of farms has more than doubled during the period 1890 to 1910, and the average size has decreased, though the farms are still large. The agriculture of the county is now in a transitional stage.

The agricultural development of the Merced area is behind that of much of the San Joaquin Valley. One reason for this is the mistakes made in the early colonization of the section. The term "col-

ony" was applied 25 or 30 years ago to the first subdivision of a large ranch into 10, 20, and 40 acre tracts, and the name has been retained until there are many such "colonies" now in the area. The first attempt at colonization, the Rotterdam Colony, begun in 1890, was a failure mainly because of the unsuitability of the soil selected and the inexperience of the men who bought the land in the methods of farming required. A number of subsequent projects have failed or have met with very indifferent success because alkali land was selected. Not only have failures brought distress and loss to the colonizers, but the misfortunes of the old colonies have had a very deterrent effect on the development of the better lands.

The first successful small farms were those on the Madera sand and the Fresno sand, near Atwater and Livingston. Notwithstanding the light texture of these soils, they have been very successfully farmed, the principal crops being sweet potatoes, peaches, grapes, and alfalfa. Efforts have been made to develop the heavy Madera soils near Merced and farther east, but success has not been so easy to attain on these as on the lighter soils. A substantial beginning has been made, however, and it seems altogether likely that when the owners learn to handle these heavy soils properly and grow only those crops well suited to them, they will meet with success.

It is impossible to obtain definite agricultural statistics for the Merced area, owing to the fact that all statistics available apply to Merced County as a whole. At the present time there are apparently more cattle in the area than ever before. They are kept, as they have been since the settlement of the area, mainly on the alkali lands in the trough of the valley (see Pl. I, fig. 1) and on the rolling hills in the eastern part of the area. They are found in greatest numbers in the irrigated sections.

The dairy industry here is well developed, and even where cattle raising is secondary to fruit growing it is probable that there are more cattle to the acre than were kept when the country was an open cattle range, and certainly more than when this part of the area was a great grain field. The open winters, favorable markets and transportation facilities, the large quantities of grain grown, and the high yields of alfalfa under irrigation all combine to make dairying a very attractive and profitable industry in the area, and it has grown rapidly in recent years. A creamery is located at Merced.

Sheep are pastured in large numbers on some of the pasture lands in the trough of the valley during the winter and taken to the foothills during the summer.

Though not so extensive as formerly, grain growing is still one of the main industries of the area. Barley is first in importance, with wheat second, and oats third. Much of these crops is cut green for hay and forage. The methods employed are those that have been in

use for many years. The ground is plowed to a depth of 3 to 6 inches with a gang plow drawn by 8 to 12 mules, plowing 6 to 10 acres a day. Most of the grain land is summer fallowed—that is, the ground is plowed in the winter or spring months and allowed to lie exposed until the next fall, when it is again plowed and then sown. Although a crop is harvested only every alternate year by this method, the yields are much larger than they were when it was attempted to produce a crop each year. The harvesting is done almost exclusively by the combined harvester, which cuts, thrashes, and sacks the grain at one operation, serving 30 to 40 acres a day. Many of these harvesters are still drawn by teams of 24 to 32 mules or horses, but traction engines for this purpose are coming into use. The engines are also used for plowing. The yields of grain vary. In seasons of very favorable moisture conditions, and upon the better soils, barley yields as much as 18 sacks[1] and wheat 14 sacks to the acre. On poorer soils with less favorable moisture conditions the yields are sometimes so low as not to pay the expense of harvesting and marketing.

Alfalfa is one of the favorite crops of the small irrigated farm. It is grown partly for market, but mostly for feed for stock. It does well on the Hanford fine sandy loam of the Merced River bottoms and on the Madera sand. It requires a great deal of water on the latter type, but the yields range from 3 to 7 tons per acre. Alfalfa also does well on the heavier types of the Madera series near Merced and to the southeast, where it is grown very extensively. On these soils it requires less water and yields are somewhat heavier. The best results from the crop in this area seem to be obtained, in the order named, from silt loam, fine sandy loam, silty clay loam, sand, clay loam, and clay soils. The heavy soils have a tendency to shorten the life of the plant. The sands are not the best soils for alfalfa, being excelled by soils of medium texture, but they are better than the heaviest types. Good drainage, freedom from alkali, and the absence of shallow hardpan are important soil conditions for the culture of this crop.

The growing of sweet potatoes is an important industry in the Merced area. They are practically all grown on the Madera and Fresno sands (see Pl. I, fig. 2). Two hundred carloads of the crop of 1913 were shipped from Livingston and 510 cars from Atwater. The industry is mainly in the hands of Portuguese, but some Italians, Greeks, and a few Americans are interested. The potatoes are put in the hotbeds in February, and the sets are transplanted in April. The transplanting is done mainly by machines, each being operated by three men. Each machine plants and waters about 5 acres a day.

[1] The "sack" varies somewhat, but averages about 2½ bushels.

Most of the cultivation is done by horse-drawn machinery. According to the texture of the soil, the crop is irrigated from one to five times. It has been found that the sand soils vary in value for the production of potatoes. The more nearly level, loamy fields make very good potato land. When these fields are new one or two irrigations give a yield of 100 to 150 boxes[1] per acre. The lightest textured sand, especially in gently rolling areas, is not so good, the potatoes requiring four or five irrigations and the yields even then dropping much below 100 boxes per acre. Much of the crop is marketed directly from the field, but some is kept in cellars for later markets. The potatoes must be handled very carefully. When they are put in the cave or cellar each potato is placed by hand, and when marketed they are carefully packed in the boxes. The work of storing and the loss from rotting are so great that an advance of 40 cents a box over the price from the field is made to cover the extra expense of handling.

The boxes in which the potatoes are shipped cost 16 or 17 cents apiece and are furnished by the shippers. The cost of producing sweet potatoes, exclusive of the rent of the land, is computed at about 50 cents per box. When land is rented on the share basis the landlord receives one-third of the crop. While yields were generally satisfactory during the year prior to this survey, averaging about 75 boxes per acre, the prices have been very low, ranging from 60 cents to $1 per box, the latter price being received for potatoes from storage, and there is a general feeling of discouragement among growers. There is no organization among the growers for marketing the product, the markets being entirely in the hands of commission merchants. Sweet potatoes are a ready-money crop, and as such are especially suited to the beginner and to the man of small means, but in the present state of the industry the more enterprising and independent growers are displacing this crop with others.

Grape growing is quite extensively developed on the light soils around Atwater and Livingston (see Pl. II, fig. 1) and to a small extent on the heavier soils around Merced. Both wine and table grapes are produced. This industry has been quite profitable and more vineyards are being set out each year. A small colony of Japanese near Livingston has been especially successful with the Thompson seedless grape. Some wine grapes have been grown for years near Snelling on the Hanford fine sandy loam. The last census reported 12,085,751 pounds of grapes grown in the county, probably most of which were grown in the area surveyed. Two-thirds of these were wine grapes. The industry has developed considerably since 1909, as is indicated by a shipment of 4,260,000 pounds from Atwater in 1913. Vines begin bearing at about 3 years of age and with good care should

[1] A box of sweet potatoes is 100 pounds net.

produce good crops for 10 to 15 years. The cost of bringing a vineyard into bearing ranges from about $75 to $100 an acre.

Peaches are one of the main fruit crops in the area and young trees are constantly being set out. They do especially well on the Madera sand around Atwater (see Pl. II, fig. 2). There were 58 cars, or 1,400,000 pounds, shipped from this station alone in 1913. Some of the fruit is placed on the market fresh, some is sold to the cannery at Atwater, and large quantities are dried. The profitableness of this crop depends upon the varieties planted and the attention given the trees. Trees come into bearing at about 3 years and continue, with good care, to produce well for 12 to 15 years. The cost of bringing peaches into bearing, exclusive of the cost of land, is about $100 to $150 an acre. Peaches are also being set out on the very heavy soils around Tuttle and Planada, but success here has not been demonstrated. The few apricots produced are grown in connection with peaches on the light soils, although the apricot is adapted to somewhat heavier soils than is the peach.

There are many fig trees scattered over the area, but usually they are isolated and planted for shade or to make a border for orchards of other fruit. There is a large orchard of Mission figs a few miles below Merced Falls on the Hanford fine sandy loam and another near Merced on the Madera silt loam. Both are said to have done well. A few orchards of Smyrna figs have come into bearing, but for some reason have not proved so profitable as expected. Quite an interest has developed in the fig industry and many young trees have been set out on the heavy soils of the Madera series near Merced. It is thought that the very heaviest soils are best suited to the fig.

Olives have been grown since the first settlement of the area, but usually only as scattered trees. The Rotterdam colony set out many olive groves, some of which remain to the present time, but they have been neglected and no profit has been derived from them. No successful commercial orchards are found in the area, but this is apparently due to neglect and mismanagement rather than to unsuitability of the soil. Quite a number of young trees are being set out as border trees around orchards of peach or other fruits. The olive does well on a wide range of soils, and many of the soils in the area are unquestionably well suited to it. It thrives on loams, gravelly loams, sandy loams, fine sandy loams, and light clay loams. The soils should be free from standing water, deep, friable, not too high in humus, and not subject to periodic overflow.

A few orchards of pears are found on the Madera sand and sandy loam and a few young orchards are being set out. All the orchards noted were more or less affected with blight, and attempts to control this disease have apparently been ineffective.

What is claimed to be the only pyrethrum plantation in the United States is located in this area. The product is sold under the trade

name of buhach and is the well-known insect powder of commerce. The Madera sand is found well suited to the crop.

A number of other crops are grown on a small scale with profit. There are a few small orchards of almonds near Merced on the lighter phases of the Madera silt loam that are doing very well, but the industry is not being developed. Apples do not do well. Oranges are an uncertain crop. They are grown for home use, and during favorable years some fruit is marketed, but it is realized that the danger from frost is too great to justify an attempt to grow this fruit commercially. A very few plums and prunes are grown.

Beans are an important minor crop. They are grown in small fields and marketed as dried beans. Eggplant is shipped from Livingston by the carload. As much as $1,000 an acre has been realized from eggplant grown on the Madera sandy loam. Cantaloupes are grown with great success on the same soils that are used for sweet potatoes. Seventy carloads were shipped from Livingston in 1913. Pumpkins, cow melons, and watermelons also are grown on a small commercial scale, especially on the sandy soils. A great many farmers make a practice of growing a small acreage of pumpkins and cow melons as feed for stock. Egyptian corn is grown quite extensively in the Stevinson colony and in a more limited way in other parts of the area. Small fruits and truck crops are produced near Merced to a small extent for the local market. Corn has been grown for a long time on the Merced River bottoms and large yields are recorded, but it has not become an important crop. There is some difficulty in getting an even fertilization of the silk over a whole field. As the prevailing winds are from the northwest, care has to be taken not to run the rows in this direction, but even under the most favorable circumstances several rows on the windward side of the field may not fill. Popcorn promises to become a valuable crop.

Farm labor is often scarce. The usual monthly wage ranges from $30 to $40 a month with board, and the daily wage from $1.50 to $2.50 without board. During harvest time $2.50 to $4 a day is paid. The rate of compensation depends upon the kind of work performed. On the smaller farms the work is largely done by the owners and their families.

Prices of land in the Merced area are in an unsettled state, owing in part to the change in agriculture now taking place. During the days when stock raising and grain growing were the only types of farming in the county land values were very low, but since it has been found that many of the better soils are capable of a highly specialized agriculture under irrigation, and the success of many of the small farmers has been assured, prices have advanced very rapidly, and in many cases with little regard to the suitability of the soil to special

FIG. 1.—ALKALI LANDS IN THE SAN JOAQUIN VALLEY SOUTHWEST OF ATHLONE.

FIG. 2.—SWEET POTATOES ON MADERA SAND.

FIG. 1.—YOUNG VINEYARD ON MADERA SANDY LOAM IN THE WESTERN PART OF THE AREA.

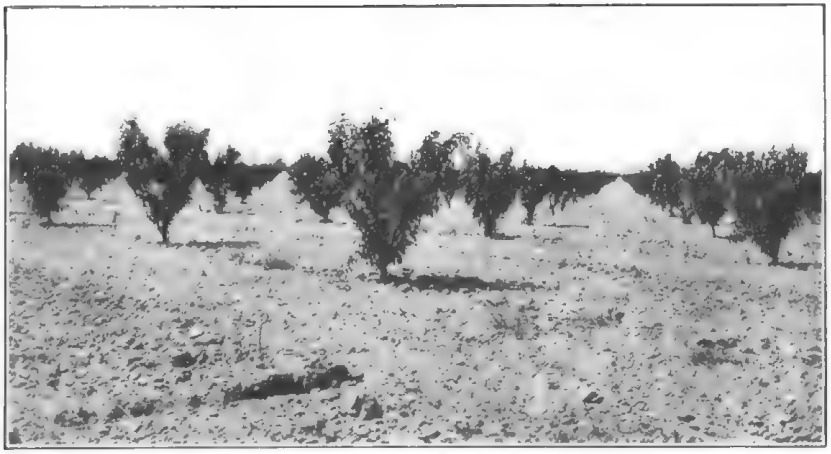

FIG. 2. PEACH ORCHARD ON MADERA SAND.

crops. At the present time prices of the better lands are not high in comparison with prices of similar lands elsewhere in California, but it is true that prices quoted and obtained bear in many cases little relation to the value of land based on productiveness. These prices will in time adjust themselves, but in the meantime little information is to be obtained from the quotation of prices on many of the types, even though these prices represent actual sales.

The foothill lands suitable only for grazing sell for about $5 an acre. The high rolling land on the eastern side of the area, which is suitable only for pasture, including the soils of the Aiken, Mariposa, and Altamont series, and the gravelly and stony types of the Redding and the San Joaquin series rent for 25 to 75 cents per acre for pasture. Land badly impregnated with alkali in the trough of the valley, mainly of the Fresno and Hanford series, suitable at present only for pasture, has a rental value of 35 to 50 cents per acre. The types suited to grain farming but with only remote possibilities of irrigation, including the Altamont sandy loam and a number of the San Joaquin and Madera soils, give returns from grain farming that would justify a capitalization of $20 to $40 an acre. Many of these types are also suited to highly specialized crops where water can be obtained, and this possibility creates a highly speculative price. The sandy soils around Atwater and Livingston, which have been found suited to fruit, truck, and alfalfa under irrigation, are valued at $100 to $200 an acre without trees. Land well set in bearing trees is worth much more. The heavy Madera types around Merced are now being set to various fruits and are selling at $150 to $300 an acre and even higher.

SOILS.

The San Joaquin Valley occupies an elongated area lying between two great mountain systems. The lifting of the Sierra Nevadas on the east and of the Coast Range on the west left this depressed area as a broad structural trough. In this process it was first an arm of the sea, and by later changes a lake, and then succeeded to its present drained condition by various oscillations. It has been the site for accumulating sediments of varied character from the Sierra Mountains since early Cretaceous, and from the Coast Ranges since Tertiary time. The Merced area, lying on the east side of the valley, has received material mainly, perhaps exclusively, from the Sierras. The existing valley floor and slopes are immediately underlain by rather recent deposits, however, which have buried the older, and it is only along the eastern edge of the area that the older rocks are found.[1]

[1] U. S. Geological Survey Professional Paper No. 73, The Tertiary Gravels of the Sierra Nevada of California, has been drawn on for the geology of the valley border. The details of the more recent geologic history are the result of researches of the soil-survey party.

The soils of the Merced area are divided according to their origin into four groups: (1) Residual soils, (2) soils derived from the old valley fillings, (3) soils derived from recent alluvium, and (4) miscellaneous material. The following table gives a classification of the soil series and types of the area according to material and origin:

I. Residual material.
  A. Metamorphosed eruptive rocks; basic schists with included vein quartz.
    1. Red soils.
      Aiken series.
        Aiken loam.
        Aiken gravelly loam.
  B. Metamorphosed shales; Mariposa slates.
    1. Brownish-yellow soils.
      Mariposa series.
        Mariposa sandy loam.
        Mariposa silt loam.
  C. Sedimentary rocks; sandstones, shales, conglomerates, sands, and clays.
    1. Brown soils.
      Altamont series.
        Altamont sandy loam.
        Altamont gravelly sandy loam.
        Altamont loam.
        Altamont gravelly loam.
        Altamont stony loam.
        Altamont clay adobe.

II. Old valley-filling material (including old alluvial-fan, delta, stream outwash plain, stream-terrace, lacustrine or marine deposits.
    1. Red soils.
      a. Hardpan in subsoil with gravel substratum.
        Redding series.
          Redding stony loam.
          Redding gravelly loam.
          Redding gravelly clay loam.
      b. Hardpan in subsoil without gravel substratum.
        San Joaquin series.
          San Joaquin sandy loam.
          San Joaquin fine sandy loam.
          San Joaquin loam.
          San Joaquin stony loam.
          San Joaquin gravelly loam.
          San Joaquin clay adobe.
          San Joaquin gravelly clay loam.
    2. Dark-gray to black soils.
      a. Red hardpan.
        Alamo series.
          Alamo clay adobe.
      b. Without true hardpan. Calcareous.
        Montezuma series.
          Montezuma clay adobe.

II. Old valley-filling material—Continued.
3. Brown soils, with gray phases.
a. Valley plains.
Fresno series.
Fresno sand.
Fresno sandy loam.
Fresno fine sandy loam.
Fresno loam.
Fresno silty clay loam.
Fresno clay.
b. High river terrace.
Oakdale series.
Oakdale sand.
Oakdale sandy loam.
III. Recent alluvium (including recent alluvial-fan and recent stream flood plain and terrace deposits).
A. Granitic rocks.
1. Brown soils.
Hanford series.
Hanford coarse sand.
Hanford sandy loam.
Hanford fine sandy loam.
Hanford silt loam.
Hanford clay loam.
B. Rocks of all kinds.
1. Brown soils.
a. With hardpan.
Madera series (includes some old valley-filling material).
Madera sand.
Madera sandy loam.
Madera fine sandy loam.
Madera loam.
Madera silt loam.
Madera clay.
Madera clay adobe.
b. Without hardpan.
Honcut series.
Honcut fine sandy loam.
2. Dark-gray to black soils.
Merced series.
Merced silty clay loam.
C. Metamorphosed sedimentary rocks.
1. Gray to drab soils.
Elder series.
Elder silt loam.
Elder silty clay loam.
Elder clay.
IV. Miscellaneous material.
Dunesand.
Riverwash.
Rough stony land.
Tailings.

The residual soils are found in the more elevated eastern and northeastern parts of the area. They are derived from consolidated

rocks of three kinds: (1) metamorphosed sedimentary rocks of Jurassic age or older, (2) metamorphosed igneous rocks, and (3) soft and but feebly consolidated sedimentary rocks. Three series of soils have been derived from these rocks: the Aiken from the rocks in group 1, the Mariposa mainly from group 2, but in part from group 3, and the Altamont from group 3.

The Aiken soils are derived predominantly from dark-colored schists formed largely from basic igneous rocks; the Mariposa soils from metamorphosed shales known as the Mariposa slates, and from the faintly consolidated Tejon sandstone, a brown sandstone containing conglomerate layers and lenses, and the Altamont soils from the Ione and Andesitic sandstone formations. The former consists of beds of silt and clay with smaller quantities of sand of varying degrees of consolidation. This gives rise to the heavier members of the Altamont series. The Andesitic formation contains more sand and less silt and clay and gives rise to the lighter soils of the series.

The remaining soils of the Merced area are sedimentary. All the area except that part occupied by the residual soils is formed of deep deposits of unconsolidated materials of varying age. These deposits comprise alluvial fans and filled-in basins. A high ridge just south of the Merced River extends west from the foothills about 12 miles. This is a part of an old fan laid down by the Merced River, when it flowed at a higher level than at present. It consists largely of coarse material. South of this ridge are large areas of finer materials representing the distal edges of the fans of the Merced River and of the smaller streams south of it and offshore deposits made in quiet water. Some of this material has been in place a sufficient length of time to develop a hardpan, but much of it is of so recent deposition that little weathering has taken place. In the western part of the area and northwest of the areas of fine materials just mentioned is a large area of light materials, mostly sand, representing a more recent fan of the Merced River than that forming the ridge of coarse material already discussed. This sand has been extended somewhat to the southeast by the winds since deposition. Extending from this sand deposit up both sides of the Merced River as a high terrace are some gray or light-brown deposits underlain by incipient hardpan.

Eleven soil series have been developed in this area from these unconsolidated materials, including the true alluvial deposits along the rivers still subject to occasional overflow. Leaving these latter out of consideration, there are seven series. They are differentiated from one another on the basis of color, the character of the subsoils and substrata, and in one or two cases the special process by which the soil material was accumulated. The recent-alluvial soils have been segregated because of their topographic position and liability

to flooding and because of differences in subsoil and substrata. The main differentiations, aside from the recent-alluvial soils, are based upon the stage reached in different parts of the area in the accumulation and assimilation of vegetable matter, in oxidation, and in the development of heavy subsoils and hardpan. Each of these groups or series is subdivided on the basis of the texture of the material. This is a factor depending mainly upon the original character of the material when deposited and to a very slight extent, if any, on development since deposition. It is a function of the geological processes of deposition rather than of the soil-making process of weathering and the effect of vegetation.

There are two groups of red soils derived from the old, unconsolidated valley-filling material, both with red hardpans in various stages of development, though usually well developed. In the one group, the Redding series, there is beneath the hardpan a substratum of porous gravels, while in the other, the San Joaquin series, this is absent and is replaced by finer grained material. The value of the differentiation, so far as it may express itself in agricultural results, is remote and confined probably to those cases where, in utilizing the soils, the hardpans are artificially broken.

There are four dark-colored groups of soils derived from unconsolidated materials. Two of them lie above ordinary overflow. One of these has a well-developed red hardpan; the other is free from hardpan, its soils are usually darker than those of the other groups, and usually more calcareous. These two groups are, respectively, the Alamo and the Montezuma series. The third group of dark-colored soils, the Merced series, is free from well-developed hardpan and is subject to overflow. The fourth group, the Elder series, is a recent-alluvial soil, free from hardpan, and in extreme cases liable to overflow. The color is medium gray to dark bluish gray.

There are two groups of gray or light-colored soils from unconsolidated materials. Two of these groups lie above overflow and one has rather well developed hardpans, though discontinuous or poorly developed in places. The Fresno series is rather light gray in color and is underlain by a white, usually calcareous, hardpan. The Oakdale series is typically without hardpan but may include a poorly developed brown or yellowish hardpan.

There are three groups of brown soils derived from sedimentary materials, all of which are subject to occasional flooding in some portions of their areas. The Madera series occupies recent alluvial fans and smooth valley plains and has a rather well developed brown hardpan, while the Hanford and Honcut series, which occur in alluvial fans and stream bottoms are free from hardpan or heavy subsoils. The Hanford is derived mainly from granitic rocks and the Madera and Honcut from mixed rocks.

There are indicated on the soil map a few bodies of Rough stony land on the edge of the foothills, some Riverwash along the Merced and Chowchilla Rivers, a small acreage of Dunesand, and Tailings from the gold dredges.

The Montezuma clay adobe is derived from beds of fine sediment laid down during the formation of the first big fan of the Merced River, and the Fresno soils are derived from beds of fine deposits laid down later. The marked difference between these two series of soils is due not to the difference in the time at which they were laid down nor to the source of material, but apparently to the fact that the Montezuma beds were early elevated from the water and have since been well drained, while the Fresno beds were farther out in the trough of the valley, have most of the time been under water, and have been elevated above standing water at a comparatively recent time. The difference is mainly a matter of weathering.

The difference in color between the Redding and San Joaquin soils on the one hand and the Montezuma soils on the other is also of interest. The Redding and San Joaquin soils have weathered to red, while the Montezuma soils in the same fan, with approximately the same period of weathering, are black. The Montezuma soils, which are all clays, show a very high lime content, and this, in connection with the organic matter, has probably produced the black color. The Redding and San Joaquin soils do not have this high lime content and neither the organic matter nor oxidation has given them a black color. The color of these soils depends almost entirely on the changes occurring in the iron. Their red color indicates an advanced stage in the oxidation of the iron, with very little humus to modify the color.

Hardpan, in the sense in which it is used in this report, is a compact and more or less cemented or indurated substratum in the soil column within 6 feet of the surface and relatively impenetrable to water and plant roots. It is of secondary development; that is, formed after the soil had been laid down. The presence of hardpan in a soil introduces conditions which materially affect the agricultural value and adaptation and may even render areas of soil absolutely worthless for agriculture.

There are two distinct kinds of hardpan in the Merced area. The hardpan under the Fresno soils is gray, and the beds frequently differ in texture from the material above and below them, while the hardpan under the San Joaquin and the Redding soils is red and does not differ materially in texture from the surrounding soil.

The cementing material of the Fresno hardpan consists usually of calcium carbonate. The degree of cementation in this hardpan varies, the layers ranging from very hard material to softer material that can be penetrated with a soil auger. There may be no evidence of stratification in the hardpan. The red hardpan under the San

Joaquin and Redding series is cemented with iron salts. The surface of the hardpan layer is very uneven.

The hardpan under the Madera soils is of the same class as that under the San Joaquin soils, but not quite so well developed. The partial hardpan under the Oakdale soils is also of the same class.

A number of soils in the area have a striking surface configuration, consisting of small mounds or hummocks 1 to 2 rods in diameter and 2 to 4 feet high occur, lying where best developed very close together. These are popularly called "hog wallows," but actually the feature is just the opposite of depressions. Narrow channels or depressions wind in and out and many of these depressions have no natural drainage. This surface configuration is almost invariably connected with hardpan and is best developed where the hardpan is near the surface. As found on the Fresno soils (Pl. I, fig. 1) it differs somewhat in appearance from that of the San Joaquin and the Redding soils (Pl. III, fig. 1), and it is probable that the mode of formation is different. The elevations here appear more like mounds on a flat surface without the undrained depressions between them. The origin of these mounds is not very clear, but their association with the hardpan is significant, and it also seems evident that erosion has been a factor in their formation.

The following table gives the name and the actual and relative extent of each of the soils mapped in this area:

Area of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Madera silt loam	81,280	13.2	Redding stony loam	6,272	1.0
Fresno sand	48,064	7.8	San Joaquin gravelly clay loam	4,864	.8
Hanford fine sandy loam	37,696	6.1	Fresno sandy loam	4,352	.7
Madera sand	36,992	6.0	Mariposa silt loam	4,032	.7
San Joaquin loam	33,664	5.5	Oakdale sand	3,968	.6
Fresno loam	33,472	5.5	Riverwash	3,776	.6
Redding gravelly loam	29,824	4.9	Hanford silt loam	2,880	.5
Fresno clay	29,056	4.7	Aiken loam	2,112	.3
Altamont loam	27,648	4.5	Rough stony land	1,984	.3
San Joaquin fine sandy loam	27,264	4.4	Hanford coarse sand	1,984	.3
Fresno silty clay loam	25,984	4.2	Elder silt loam	1,792	.3
San Joaquin sandy loam	24,640	4.0	Elder silty clay loam	1,664	.3
Merced silty clay loam	18,432	3.0	Mariposa sandy loam	1,536	.3
Altamont sandy loam	16,256	2.6	Madera fine sandy loam	1,472	.2
Madera sandy loam	16,000	2.6	Honcut fine sandy loam	1,408	.2
Madera loam	15,808	2.6	Redding gravelly clay loam	896	.2
Madera clay	13,312	2.2	San Joaquin clay adobe	704	.1
Hanford sandy loam	11,072	1.8	Hanford clay loam	640	.1
Oakdale sandy loam	11,072	1.8	Madera clay adobe	448	.1
Alamo clay adobe	4,224	1.5	Tailings	320	.1
Well-drained phase	4,992		Dunesand	256	.1
Fresno fine sandy loam	6,912	1.1	Elder clay	256	.1
Montezuma clay adobe	6,784	1.1			
Altamont clay adobe	6,336	1.0	Total	614,400	

Aiken Series.

The soils of the Aiken series range in color through various shades of red to dark reddish brown, the surface, owing to accumulations of organic matter, being sometimes dark brown with but little red. Angular to subangular rock fragments, frequently of large size, are numerous. The subsoils are bright red to brick red or dark red in color, heavy and compact, and frequently underlain at shallow depths by bedrock. The soils are usually well drained and retentive of moisture, although in places drainage may be excessive. They occupy mountain and foothill slopes or plateaulike uplands, the surface varying from sloping to steep, rough, and broken, with frequent rock outcrops. The soils of the series are of residual origin and are derived mainly from basaltic andesitic or metamorphosed basic igneous rocks. The timber-growth varies from sparse to heavy.

Aiken loam.

The Aiken loam is a red to yellowish-red soil, usually shallow in depth and low in organic matter. In texture it ranges from a loam to a light loam, which may closely approach a sandy loam. The subsoil is similar to the surface soil and shallow or thin. In places the surface soil rests directly on the bedrock, which frequently outcrops. On the ridges the soil is 2 inches to a foot in depth, while in the hollows, where it is composed largely of colluvial material which has found its way down the slopes largely by gravity, it may be 3 to 4 feet deep. Small quantities of bowlders or rock fragments occur in the soil material. Some small undifferentiated bodies of brownish-yellow soil, probably material of the Mariposa series, occur in the type as mapped.

This is a minor type, occurring in the northeastern part of the area and in small bodies in the eastern part. It forms the western limits of the true foothills.

The topography is rolling to steep, and the type is subject to erosion. Drainage is excessive and the soil is of low moisture-holding capacity. In the main it is not adapted to irrigation, but occasional small bodies of a few acres occur in hollows that could be irrigated to advantage if water were obtainable. At present most of the type is used for pasture, but the quantity of grass produced is not very large. Twenty acres or more are required to pasture a steer through the season. A few acres in the extreme northern part of this area are cultivated by dry-farming methods and light crops of grain are produced.

The following table gives the results of a mechanical analysis of a sample of the soil of the Aiken loam:

Mechanical analysis of Aiken loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572630	Soil	5.0	7.5	4.6	16.4	18.0	38.6	10.0

AIKEN GRAVELLY LOAM.

The Aiken gravelly loam, which is shown on the soil map by gravel symbol in color of the Aiken loam, is a light-red to red loam containing quartz and andesitic gravel. It is shallow, ranging from a few inches to a foot in depth, and is low in organic matter. In depressions and on lower slopes it sometimes includes colluvial material and may be somewhat deeper. It usually rests directly on the bedrock which is identical with that found under the Aiken loam. This rock outcrops in many places.

This type occurs only in small areas in the northern part of the survey. Its topography is rolling to steep and rough. Erosion is excessive. The Aiken gravelly loam is used solely for pasture. It produces only a scant growth of grass.

MARIPOSA SERIES.

The Mariposa series consists of types with yellow to grayish-yellow or brownish-yellow surface soils and subsoils occurring on the edge of the foothill region in the northeastern part of the area. These are very shallow soils of rolling to steep topography, and occasionally precipitous next to the drainage channels. The native vegetation is grass, with a scattered growth of deciduous oaks.

They are residual soils, derived mainly from metamorphosed shales called the Mariposa slates, belonging to the Bedrock series. As recognized in this survey, however, some material of similar color and derived from unaltered sedimentary rocks is included. The rock strata of the slates are nearly vertical and the trend is from northwest to southeast. When the rock is only slightly metamorphosed the shales are light in color and the soil is dominantly yellow. Small included areas of dark slates, highly metamorphosed, produce drab or dark-gray soils in areas too small in extent to be differentiated. If more extensive these would be recognized under a distinct series.

MARIPOSA SANDY LOAM.

The Mariposa sandy loam is a light yellowish brown or brownish-yellow sandy loam, a few inches to 2 feet deep, underlain by a subsoil

of similar color and texture, except in places where the surface soil rests directly upon the rock from which it is derived. In texture the type is subject, as mapped, to considerable variation. In some places the material approaches a loam, while again, as indicated by mechanical analysis, it closely approaches a sand. It has a moderate amount of gravel and cobbles, derived, evidently, from a conglomerate. Broken fragments of the sandstones which produced the main body of the soil are also found in varying quantities. This bedrock represents various strata of the Tejon formation and consists of brown sandstones and conglomerate. Considerable mica appears in the sandstone and also in the soil.

This type occurs in a few small bodies directly on the eastern border of the area. The Tejon formation from which it is derived has been largely eroded away and is now represented only by isolated, flat-topped buttes, mapped as Rough stony land, surrounded by lower, rounded hills of the resulting soil, the Mariposa sandy loam.

The Mariposa sandy loam as it occurs in this survey differs somewhat in origin from the Mariposa series as typically developed and as previously defined. Unlike the true Mariposa soils, it is derived from horizontal beds of Tertiary age on the western border of the foothills of the Sierra Mountains. It is easily distinguished from the Aiken and from the true Mariposa series, which are derived from uplifted metamorphosed rocks, in coming from horizontal beds, and from the former by a distinct difference in color. It is distinguished from the Altamont series, which are also derived from horizontal beds of Tertiary age, by being yellowish rather than brown.

This is an unimportant soil type, included with the Mariposa series in this survey owing to the similarity of soil material.

Erosion is active, drainage is excessive, and the soil is not adapted to irrigation. It is used exclusively for pasture. It is of low moisture-holding capacity and produces a scant growth of grass of only fair value. The type is treeless, but a growth of live oak is a noticeable feature of the buttes of Rough stony land that crown many of the higher hills. The oaks are found on the broken, stony part of the buttes at and near the top, but occur nowhere else in the vicinity.

The following table gives the results of a mechanical analysis of a sample of the soil of the Mariposa sandy loam:

Mechanical analysis of Mariposa sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572651	Soil	9.6	10.8	4.0	26.4	17.0	25.2	6.9

MARIPOSA SILT LOAM.

The Mariposa silt loam is a pale-yellow or light brownish yellow to grayish-yellow, rather heavy silt loam, varying from 6 inches to 18 inches in depth on the ridges and from 2 to 3 feet in the depressions, where the material consists largely of wash from the surrounding hillsides. The soil contains large quantities of small slate fragments and also more or less quartz gravel resulting from the weathering of included quartz veins. The content of organic matter is low. The material rests directly on bedrock, which in many places protrudes in thin slabs 1 to 6 feet deep. As mapped in this survey the type includes some undifferentiated red soils of the Aiken series, and also a few small patches of dark soils derived from the Mariposa slates and of too dark gray color to be properly included with the Mariposa series if of sufficient extent to warrant separation.

This type occurs in a few small bodies on the northeastern boundary of the area, but is extensively developed in the region east of the survey.

The topography is rolling to steep and erosion is very active. Drainage is excessive and the soil is of low moisture-holding capacity and subject to early drought. The type is used exclusively for pasture. It produces an early but scant growth of grass.

In the following table the results of a mechanical analysis of a sample of the soil of the Mariposa silt loam are given:

Mechanical analysis of Mariposa silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572631	Soil	3.2	4.6	2.6	11.0	14.4	51.8	12.4

ALTAMONT SERIES.

The surface soil of the Altamont types are light brown to dark brown. The subsoil is a heavy, rather compact clay, of reddish-brown or light-brown color, and usually of heavier texture than the surface soil. It rests on bedrock. Angular rock fragments occur on the surface and throughout the soil. This series occupies hilly to mountainous country, dissected by gulches and ravines, frequently with steep slopes, upon which numerous rock outcrops occur (see Pl. III, fig. 1). The soils are well drained, but retentive of moisture. The members of this series are residual in origin, being derived from the decomposition of interbedded sandstones and shales (see Pl. III, fig. 2). In areas of low rainfall they are practically treeless, but where the precipitation is sufficient they support a good forest growth.

ALTAMONT SANDY LOAM.

The soil of the Altamont sandy loam is from 1 foot to 2 feet deep, and consists of a light-brown to grayish-brown sandy loam, usually of light texture and sometimes approaching a sand. It is loose in structure, low in organic matter, and easy to cultivate. It contains varying quantities of coarse, angular gray sand and the dry surface in cultivated fields is frequently of light-gray color. The subsoil is a light grayish brown to yellowish-brown sandy loam to loam. The underlying soft sandstone rocks are often reached on the hillsides at depths of 2 to 6 feet. The soil varies much in texture. The tops, sides, and lower slopes of the hills are seldom of the same texture, being influenced by the different strata from which they are derived. Areas of sand, fine sandy loam, and loam occur, but these are too small to be mapped separately. Both soil and subsoil absorb rainfall readily and retain it remarkably well considering the surface slope. A small quantity of waterworn gravel is scattered over the surface in places, being apparently derived from remnants of the Redding soils which occasionally remain as patches capping hilltops or on the hillsides.

The largest body of Altamont sandy loam is found in the northeastern part of the county. There are a few other small areas in this part of the area.

The topography is rolling, the type occupying smooth, rounded hills. The elevation ranges from 50 to 125 feet in cross section. The hills are strictly erosional and the drainage is dendritic. The type is well to excessively drained.

This soil has been used for pasture and grain farming and has been very lasting under the latter use. It still produces profitable crops of barley and oats. In favorable years barley yields 10 to 15 sacks and oats 10 to 20 sacks per acre. It would be a very difficult soil to irrigate in this area, however, on account of its rolling topography.

The results of mechanical analyses of samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Altamont sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572645	Soil	3.2	14.8	9.0	28.4	18.2	17.2	9.4
572646	Subsoil	2.9	10.3	6.0	22.6	21.6	25.5	11.1

ALTAMONT GRAVELLY SANDY LOAM.

The Altamont gravelly sandy loam is a brown to light grayish brown sandy loam containing gravel and cobblestones. It is 1 to 2

feet deep, is without a distinct subsoil, and is underlain by yellow and brown sandstones or gray silty deposits. It is low in organic matter.

This is an inextensive type, found only in one body lying in the northeast part of the county south of Merced Falls. It is indicated on the soil map by gravel symbols in the Altamont sandy loam. The topography is rolling to hilly and the surface is covered with hummocks similar to those found on the adjoining Redding soils. It is subject to severe erosion. The gravel and cobblestones are similar to those found in the Redding soils and have evidently been left where the Redding soils have been eroded away.

The Altamont gravelly sandy loam is used solely for pasture. It supports a fair growth of grass in years of ample rainfall. It takes from 15 to 20 acres to pasture a steer in an average year.

Small undifferentiated areas of dark-gray or nearly black color are included. These would, if of sufficient extent, be recognized under a distinct soil series.

ALTAMONT LOAM.

The Altamont loam is a light grayish brown to medium grayish brown, friable loam, 6 to 24 inches deep, often becoming light gray on dry cultivated surfaces. The subsoil is similar to the soil in color, texture, and structure. The type is low in organic matter. Bedrock, consisting of soft sandstones or partially cemented, gray to dark-gray clays and silts, usually occurs at a depth of 1 foot to 3 feet. In places gravel and rounded cobbles are scattered over the surface in considerable quantities and to some extent throughout the soil. As mapped the type includes small undifferentiated areas of soils of dark-gray or black color, which if more extensive would be recognized under a distinct series head.

This type is found in the northern and eastern parts of the county, north and south of Merced River, and along the headwaters of Owens Creek. A small area lies near Amsterdam. This type has a rolling to rough topography, some of it approaching Rough broken land. It is deeply cut by erosion, and some of the hills occur as steep buttes. Drainage is good to excessive.

All of this type is used as pasture land, to which purpose it seems best adapted under present conditions. It produces a scant growth of grass of only fair quality.

ALTAMONT GRAVELLY LOAM.

The Altamont gravelly loam is a light-brown to medium-brown or light grayish brown loam, from 6 inches to a foot deep, containing gravel and rounded cobblestones scattered over the surface and, to

some extent, through the soil. The gravel is composed of andesite, quartzite, and quartz rocks.

Immediately below the soil is the bedrock, which consists of gray cemented silts and clays and brown sandstones. Well-developed hummocks occur over most of the surface.

As mapped in this survey small areas of darker colored soils, which if more extensive would be recognized under a distinct series head, are included. Small areas of the lighter gray soils of the Arnold series, which owing to small extent is not mapped in this survey, are also included.

This is an inextensive type indicated upon the soil map by gravel symbol over the color of the Altamont loam. It occurs in the northeast part of the county, south of the Merced River, and north of Mariposa Creek. It is rolling in topography, but the hills are less abrupt and steep than those in the Altamont loam. The drainage is good to excessive. It is used entirely for pasture. About 20 acres are required to pasture a steer during an average season.

ALTAMONT STONY LOAM.

The Altamont stony loam is a brown to grayish-brown loam, from 6 to 12 inches deep, underlain by the gray tufaceous rocks of the Ione formation. On the surface, and to some extent through the soil, occur large quantities of gravel and cobblestones of andesite, quartzite, and chert, most of them between 3 and 8 inches in diameter. These rock fragments bear no relation to the fine-earth material of the soil. The soil is low in organic matter. The surface is covered with numerous hummocks.

This type is found in the northeast part of the county, south of the Merced River and north of Bear Creek, where it is associated with the Altamont gravelly loam. It lies lower in elevation than the adjoining Redding soils and has evidently been uncovered by erosion, the stones being remnants of the Redding materials.

The topography is rolling with abrupt slopes along some of the stream courses. It is used extensively for pasture and has about the same value as the Altamont loam and gravelly loam.

Included with this type are small areas of dark-gray material and others of lighter gray color. These represent soils of other series, but their extent was not sufficient to warrant separation.

ALTAMONT CLAY ADOBE.

The Altamont clay adobe is typically a dark-brown to dark grayish brown clay of adobe structure, underlain by a heavy and usually calcareous subsoil of similar color or lighter brown, which rests at a depth of 12 to 24 inches upon the parent bedrock. As mapped in this

area, however, a large part of the soil material is dark gray to nearly black and properly belongs to the Diablo or some related series of soils. These variations of dark brown, dark grayish brown, and dark gray are so intimately blended that differentiation upon the adopted scale of mapping was, especially in view of the minor agricultural importance of these soils, unwarranted. The soil is rather low in organic matter. Some cobblestones and smaller gravel, derived from Redding material that has mainly been removed by erosion, occur in many places.

This type forms narrow strips on hillsides, where it is associated with other members of the Altamont series or with those of the Redding and San Joaquin series, as more extensive bodies occupying small basins and surrounded by other members of the Altamont series, and in places capping small hills. It is found in the northeastern part of the area north and south of Snelling and northwest of Hopeton. Smaller developments occur in the eastern part of the area. The general topography is rolling to sloping. Most of it is well drained and subject to erosion. It is not located so that it could be irrigated readily.

The type is treeless and is used for pasture or grain production, according to the use of the larger areas of soils with which it is associated. It is an unimportant type and occurs for the most part in such small, scattered areas that no crop adaptation has as yet been worked out on it. This soil produces a more abundant growth of grass than the adjoining lighter types. Wild oats do especially well.

In the following table the results of a mechanical analysis of a sample of the Altamont clay adobe are given:

Mechanical analysis of Altamont clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572649.....	Soil.....	0.7	2.1	1.6	7.0	13.6	37.4	37.2

REDDING SERIES.

The soils of the Redding series range in color from yellowish red or brownish red to deep red, and nearly always contain large quantities of quartzose gravel. The subsoil is red, heavier in texture than the surface soil, and rests on an impervious hardpan, usually free from gravel. Beneath the hardpan occurs a substratum of gravel in a matrix of clay or sand, which in places may be partially cemented. The Redding soils are derived from old alluvium and usually occupy elevated alluvial fans or terraces, often badly eroded, with a hummocky surface.

REDDING STONY LOAM.

The Redding stony loam is a dull-red loam, from 1 foot to 3 feet deep, low in organic matter, containing a high percentage of cobblestones and smaller gravel, derived mainly from andesitic and quartzitic rocks. This surface material is underlain by a red conglomerate hardpan from 1 foot to 2 feet thick. Below the hardpan the substratum consists mainly of beds of large and small gravel, with more or less mottled clay. The texture of the surface soil varies considerably. On the tops of the many small mounds it may be a sandy loam, while in the depressions between the mounds it is sometimes a dark-gray clay loam.

The type is found in the northeastern part of the area, occupying the crest of the large ridge which appears to be a remnant of an old fan deposit laid down by the Merced River. This consists of rolling hills reaching 100 to 200 feet above the surrounding plains. The surface is covered with well-developed hummocks, many of them of good size, as much as 4 feet high, and often close together. The cobblestones on the surface have accumulated in the depressions. Erosion of this type takes place slowly, owing to the presence of the cobblestones and to the indurated character of the substratum.

Surface drainage is good, but subsurface drainage is retarded by the hardpan. The type is used entirely for pasture, which at the present time seems to be its best use.

REDDING GRAVELLY LOAM.

The Redding gravelly loam is a red or dull-red loam, containing a large quantity of gravel and some cobblestones, and averaging about 24 inches in depth. The soil becomes very hard when dry, but does not become boggy when wet, on account of the gravel. At a depth of about 16 to 30 inches, where typically developed, there is a red, well-cemented iron hardpan stratum about a foot thick. The soil material in minor depressions is often dark gray in color and the hardpan lies within 12 to 18 inches of the surface. Below this hardpan the subsoil consists of cobblestones in a matrix of heavy soil material usually of grayish color. In places it consists solely of cobblestones, with some of the less resistant rocks in an advanced state of disintegration. The gravel and cobblestones are more or less cemented.

The Redding gravelly loam occurs in large areas in the northeastern part of the survey, extending from the northernmost part along the eastern border south to Bear Creek. Its most important development is a few miles south of the Merced River, where a large, high ridge extends into the valley for a distance of about 15 miles. This is

FIG. 1.—SOILS OF THE ALTAMONT AND REDDING SERIES IN THE EASTERN PART OF THE SURVEY, SHOWING THEIR GENERAL TOPOGRAPHY AND TREELESS CHARACTER.

Rocky hill in distance on right is Tejon formation, mapped as Rough stony land.

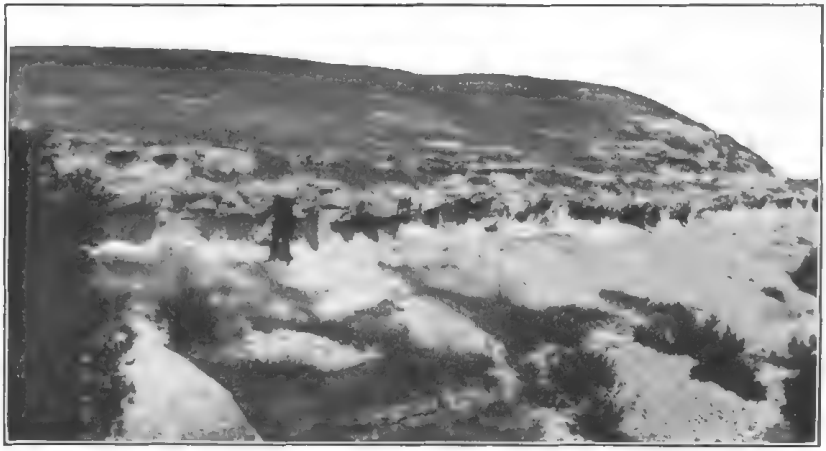

FIG. 2.—OUTCROP OF HORIZONTAL BEDS GIVING RISE TO SOILS OF THE ALTAMONT SERIES.

FIG. 1.—WILD HAY CUT ON HEAVY SOILS OF THE SAN JOAQUIN SERIES.

FIG. 2.—GRAIN HAY ON MADERA LOAM.

probably the remnant of the central part of the old Merced River fan, which has evidently resisted erosion on account of the large admixture of partially cemented rock fragments.

The type occupies rounded hills lying from 100 to 200 feet above the adjoining plains, the surface being marked by the characteristic small "hog-wallow" hummocks occurring in the soils of this series. The type is not well suited to irrigation. Surface drainage of the type is well developed, but the subdrainage is restricted.

During the great expansion of grain growing in the Merced area, about 1890, some of this type was plowed and sowed to grain, but profitable crops could be obtained only in very favorable years, and it has consequently all been returned to pasture. Ten to twelve acres of this land are required during an average year to support one steer. It furnishes good pasture in winter, but not so good in summer, during which the cattle are turned into the stubble fields. It rents for 75 cents an acre for pasture.

There are very few improvements on the type, and the few houses on it are mainly abandoned. The fences are good.

REDDING GRAVELLY CLAY LOAM.

The Redding gravelly clay loam is a dark-red clay loam, from 1 foot to 3 feet deep, with considerable gravel and some cobblestones scattered over the surface and through the soil. Beneath this surface material, at depths ranging from 6 to 12 inches, a red hardpan is encountered, and below this are the gravelly beds forming the characteristic substratum of the soils of the Redding series.

The gravelly clay loam is an unimportant type and is found in only a few small bodies, one of which occupies a hill in the northern part of the area, 3 miles west of Snelling, and another lies near Rotterdam. The surface is smooth or marked with small "hog-wallow" hummocks and depressions. It is used exclusively for pasture.

Surface drainage is, in general, adequate, but internal drainage is impeded by the impervious substratum, and pools of water occupy the minor depressions during the rainy season until removed by evaporation.

San Joaquin Series.

The soils of the San Joaquin series are prevailingly some shade of red or reddish brown and frequently gravelly. Both the finer soil particles and gravel are rounded. The soils are underlain at depths ranging usually from 2 to 3 feet by red or mottled indurated clay or sandy layers, and sometimes by gravel and cobblestones cemented by iron salts into a dense, impenetrable hardpan, which occasionally outcrops at the surface. The soils are generally of compact structure, sticky, quite readily puddled when wet, and frequently separated from the underlying hardpan by subsoils of true adobe struc-

ture. They are derived from sediments of early Pleistocene age, sometimes modified by more recent reworking or by alluvium washed from adjacent formations. They occupy level to undulating or rolling valley plains extending from low rolling foothills down to level valley floors and margins of present stream flood plains. The soils are usually treeless, except in the immediate vicinity of stream channels. Natural drainage is restricted by topographic position, slight slope, and the presence of hardpan, except in the case of the lighter, deeper members and areas occupying higher slopes.

SAN JOAQUIN SANDY LOAM.

The soil of the San Joaquin sandy loam is typically of a red color and sandy loam texture and from 18 to 30 inches deep. As developed in this area, however, much of it is reddish brown, approaching in color the brown soils of the associated and related Madera series. It is friable in structure and easy to cultivate under proper moisture conditions, but becomes compact when dry and, owing to imperfect subdrainage, is inclined to be sticky and miry when soaked by rains or irrigation water. The soil is rather low in organic matter. It is underlain by an impervious, red, ferruginous sandy hardpan a few inches to several feet thick, with an average of about 1 foot. The subsoil material below the hardpan is a brown to reddish-brown loam to clay loam.

Extensive areas of the San Joaquin sandy loam occur in the northern part of the area, and smaller bodies north of Merced. There is also a large body in the southeastern part of the area around Dickinson. This type is found on the outer edges and in the lower portions of the older valley-filling material, lying below the gravelly and heavy members of the same series and usually just above some member of the Madera series.

The topography is gently rolling to undulating, the areas having the features of an extensive plain cut by innumerable drainage channels into small ridges, hillocks, and gentle slopes. A small proportion of the type shows the hummocks so characteristic of the series as a whole. None of it is too rough or steep for cultivation. The surface drainage is good.

Most of the type is in large grain farms. In favorable years yields of 15 to 20 sacks of oats and 5 to 15 sacks of barley, with large yields of grain hay, are obtained. In dry years the yields are low, the crops sometimes being an entire failure.

This soil is only fairly well adapted to irrigation, on account of its uneven topography and the nearness of hardpan to the surface, though where the hardpan is not thick it could be blasted through and the type profitably used, if water can be obtained, for the production of peaches, grapes, figs, olives, almonds, plums, alfalfa, and truck.

There are few houses on this type and very little development is taking place.

The following table gives the results of a mechanical analysis of a sample of the soil:

Mechanical analysis of San Joaquin sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572614	Soil	1.0	15.0	12.0	30.0	18.2	17.4	6.4

SAN JOAQUIN FINE SANDY LOAM.

The San Joaquin fine sandy loam is a red or dull-red to light brownish red fine sandy loam, sometimes of rather heavy texture, and in places approaching the brown color of the soils of the Madera series. As mapped, some true Madera material has doubtless been included. The subsoil is similar to the soil or of heavier texture and extends to a depth of 18 to 36 inches.

In numerous small depressions the soil is dark grayish brown in color and a loam or clay loam in texture. Immediately beneath the soil or separated from it by a red clay loam subsoil 6 to 12 inches thick, is a red iron hardpan, usually from 1 foot to 2 feet thick, but ranging in thickness from 4 inches to 3 feet, the material underlying it being a loam or fine sandy loam, not so highly oxidized as the surface soil, and mottled with red, yellow, and gray.

The soil is friable and easy to cultivate when handled under favorable moisture conditions, but is inclined to bake and become hard during long periods of drought. It also becomes miry during the rainy season, owing to imperfect internal drainage. In places the soil contains a little gravel. It has in general a low content of organic matter.

The San Joaquin fine sandy loam occurs in large bodies in the northern part of the area near Ryer, northwest of Merced, in some small areas near Le Grand, and in the valley of Dry Creek. It has the topography of a gently undulating or gently sloping plain, well drained by numerous channels which reach every part of the type and cut the surface into a succession of gentle, low, broad ridges. The hummocks characteristic of the series, as a whole, are seldom found on this type, and where they do occur they are feebly developed.

The greater part of the type is used for the growing of grain and grain hay under dry-farming methods, and the yields are very satisfactory. This method of farming ordinarily gives returns that would justify a value of $30 an acre for the land. It is fairly well

situated for irrigation, and under irrigation could be used for the production of the same crops as the San Joaquin sandy loam.

The following table gives the average results of mechanical analyses of samples of the soil of this type and the result of a mechanical analysis of the subsoil:

Mechanical analyses of San Joaquin fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572615, 572621.....	Soil.....	0.7	9.3	7.0	23.6	23.7	27.1	8.5
572616.....	Subsoil.....	1.2	12.4	8.0	21.6	15.8	27.0	13.4

SAN JOAQUIN LOAM.

The San Joaquin loam, though in places it may approach a clay loam in texture, is typically a dull-red loam, 2 to 3 feet deep, of compact structure, and low in organic matter. The subsoil is a brown or reddish-brown clay loam, 6 to 12 inches deep, resting on a red hardpan layer from 6 inches to 2 feet thick. There are generally some gravel and a few hard andesitic cobblestones scattered over the surface and through the soil. This soil is somewhat difficult to till and must be handled under favorable moisture conditions to prevent puddling.

This type occurs in areas of considerable size in the eastern and southeastern parts of the area. It occupies low, gently rolling elevations, and the surface is usually covered with hummocks. The surface drainage is good, but internal drainage is slow, being retarded by the impervious hardpan. The type is subject to severe erosion.

The San Joaquin loam is fairly well suited to irrigation where water can be obtained. At present it is used almost entirely for pasture, about 12 acres being required to support a steer through the season. The little land that is plowed gives very satisfactory yields of grain and hay.

Average results of mechanical analyses of samples of the soil of the San Joaquin loam and the results of a mechanical analysis of the subsoil are given in the following table:

Mechanical analyses of San Joaquin loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*
572637, 572622....	Soil.....	2.3	6.4	4.5	18.3	17.6	35.2	15.6
572638.....	Subsoil.....	2.3	6.4	6.2	16.0	15.0	21.4	32.4

SAN JOAQUIN STONY LOAM.

The San Joaquin stony loam is a dull-red stony loam from 1 to 3 feet deep, underlain by a red hardpan, from 1 to 2 feet thick, which in many places carries many imbedded cobblestones. Just above the hardpan there is occasionally a stratum a few inches thick of a compact red clay, and below it is a mottled clay also containing cobblestones. The texture of the surface soil varies considerably; on the tops of the numerous small mounds it may be sandy loam and in the depressions between the mounds clay loam. The soil in the latter positions is likely to be gray in color.

This soil is found in the northeastern part of the area. It occupies a gentle slope below the high ridge of Redding soils south of it. The surface is covered with well-developed hummocks, many of them of good size. The cobblestones on the surface have a decided tendency to accumulate in the depressions.

The San Joaquin stony loam is shown on the map by stone symbols in the San Joaquin loam. It is used entirely for pasture, which seems to be its best use at the present time.

There are small areas of Redding soils included with this type.

SAN JOAQUIN GRAVELLY LOAM.

The San Joaquin gravelly loam is indicated on the soil map by gravel symbols over color of the San Joaquin loam. It is a red gravelly loam, about 24 inches deep, resting on a red iron hardpan, with an average thickness of 1 foot. The hardpan is hard and impervious to water and the roots of plants. Just above this hardpan a layer of red tenacious clay 2 or 3 inches thick is found in some places. The material below the hardpan varies. In certain areas it is a loam or clay loam, mottled with red, yellow, and gray, and where approaching the Redding soils it usually contains some cobblestones.

The San Joaquin gravelly loam occupies scattered areas in the eastern part of the survey, extending from the northernmost part along the eastern border nearly to the southern part and reaching 15 miles west toward the central part of the area. The topography varies from gently rolling to nearly level, but all the surface is marked by small mounds. The type is all well drained. It is not well suited to irrigation.

When grain growing was at its height about 1890, a considerable part of this type was used for grain crops, though profitable returns were obtained only in favorable years. At the present time the type is used for pasture, for which it is better adapted than for cultivation. In average seasons it requires from 10 to 12 acres to support a steer. It furnishes splendid winter pasturage, but the summer pasturage is

poor, and the cattle are transferred to the stubble fields. The pasture land rents for 75 cents an acre.

There are practically no improvements on the type, and the few houses found are mostly abandoned. The pastures are very large and well fenced. As mapped in this survey, some areas of Redding soils are included.

SAN JOAQUIN CLAY ADOBE.

The San Joaquin clay adobe is a dull-red or brownish-red clay, 18 inches to 3 feet deep, with a pronounced adobe structure and a fair percentage of organic matter. The soil is very heavy. It puddles badly when wet and is very hard when dry. It usually contains varying quantities of large and small gravel of the same lithological character as the gravelly members of the series. In places there is a subsoil layer of yellowish-brown clay or clay loam 1 foot to 2 feet thick, in others a red iron hardpan is found immediately below the surface. Such a hardpan always is encountered somewhere between 18 inches and 5 feet below the surface.

This is an unimportant type, occurring only in small areas, two of which lie about 7 miles north of Merced and two east of Le Grand. It occupies very gentle slopes and rounded hills, and the surface is smooth. Surface drainage is good, but the subdrainage is inadequate. Erosion is not very active.

The type supports a fair growth of grass, and is used mainly for pasture (see Pl. IV, fig. 1). A small part of it is sowed to grain, of which fair yields are obtained in favorable years (see Pl. IV, fig. 1).

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the San Joaquin clay adobe:

Mechanical analyses of San Joaquin clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572623	Soil	1.2	3.2	2.2	6.2	10.1	34.2	43.0
572624	Subsoil	.4	1.0	.9	5.0	14.5	55.2	23.0

SAN JOAQUIN GRAVELLY CLAY LOAM.

The San Joaquin gravelly clay loam is a dull-red, compact clay loam, from 1 foot to 3 feet deep, containing considerable gravel and some larger rounded rock fragments scattered over the surface and through the soil. It is low in organic matter and is readily puddled if cultivated when too wet. During the dry season it bakes and becomes very hard. It is underlain by a red hardpan 6 inches to 2 feet thick. The subsoil material below the hardpan is a red, yellow, and gray mottled clay loam, usually containing some cobblestones.

In places this type approaches and merges into the soils of the Redding series and, as mapped, it may include some areas of true Redding material.

This is a type of minor importance. There is an area of fair size surrounding the irrigation reservoir called Lake Yosemite and a few areas 7 miles east of Le Grand. Two small areas occur in the extreme northwestern part of the area. Some of this type surrounds monadnocks of the Tejon formation. It occupies very low, gently sloping hills. Surface drainage is well developed, but subdrainage is restricted. The surface is smooth or marked with small hummocks. The type is used exclusively for pasture.

Alamo Series.

The Alamo series includes types with dark-gray or dark-drab to black, in places dark reddish brown, soils underlain at depths ranging from 15 inches to 5 feet by a red or grayish-red mottled iron hardpan. They are derived mainly from the materials giving the San Joaquin soils, which materials form certain sedimentary beds of Pleistocene age. The materials subsequently to their deposition have been modified by extensive and periodical overflows, with the resulting accretion of finer river sediments and organic matter. The Alamo soils occupy lower lying flat plains and basins of deficient drainage, frequently marked by intermittent lakes and sloughs, and in places by the occurrence of swamp vegetation. They are usually treeless, except for a few willows growing near stream courses.

Alamo clay adobe.

The Alamo clay adobe is a dark-gray to nearly black clay with a pronounced adobe structure, from 2 to 4 feet deep, resting upon a red ferruginous hardpan.

A few bodies of the Alamo clay adobe are mapped in the northeastern and eastern parts of the area, where the type is closely associated with the San Joaquin soils, and many areas too small to be shown on the map are scattered through areas of soils of the latter series. The type appears to have been formed partially by alluvial wash from the higher lying San Joaquin soils. Its color is probably largely due to poor drainage, which has retarded oxidation of the iron.

As developed in this survey, the type is smooth and nearly level and slightly depressed below the surrounding soils. Both surface drainage and subsurface drainage are likely to be poor, but no alkali is found in the soil. Owing to its small extent, this type is used for pasture or grain, according to the use of the surrounding soils. Crop yields are medium.

Alamo clay adobe, well-drained phase.—The well-drained phase of the Alamo clay adobe, indicated by cross lines on the soil map, occurs in scattered bodies in the northeastern and eastern parts of the area, occupying slight elevations or gently sloping hillsides. The soil is generally dark gray to black in color, but in places it has a reddish or brownish tinge. As mapped, the phase may include small areas of undifferentiated material of the Montezuma, Altamont or San Joaquin series. On account of its location and topography, this phase has good surface drainage, but subdrainage is restricted by a hardpan substratum.

The phase is used for the same purposes as the adjoining soils, mainly for pasture. There is usually a marked difference in the growth of grasses on the Alamo and San Joaquin soils, making it easy to distinguish the small areas of the Alamo. The surface is smooth instead of hummocky, and this also serves to distinguish the two series. Stockmen state that the grass on this type is more abundant and persistent than that on the adjoining San Joaquin soils.

The results of a mechanical analysis of a sample of the typical Alamo clay adobe are given in the following table:

Mechanical analysis of Alamo clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572625	Soil	0.6	2.8	2.0	5.6	10.6	37.0	41.5

MONTEZUMA SERIES.

The Montezuma soils are dark gray or black in color, very calcareous, and have no true hardpan. The subsoils are yellowish in color, highly calcareous, and carry light-colored nodules, concretions, and thin seams or crusts of lime. In age and mode of formation these soils are closely related to the San Joaquin and Redding soils, with which they are associated. Owing to the different conditions under which weathering processes have taken place, however, they differ from the San Joaquin and Redding in color. As they occur in this area the Montezuma soils occupy low, gentle slopes and hills and have a smooth surface. They are treeless and were originally covered with a good growth of grass. The soil material has been derived from the weathering of beds of very fine unconsolidated material laid down during the time of the early valley filling. They carry a high percentage of lime, and this, in connection with the organic matter added later, has given them their dark color on weathering. As mapped in this area, small portions of Alamo, Madera, San Joaquin, and Redding soils are included.

MONTEZUMA CLAY ADOBE.

The Montezuma clay adobe is typically a dark-gray or black clay, 24 to 36 inches deep, having all the tendencies to check, crack, and assume an open structure upon drying characteristic of soils of adobe structure. When wet the soil is very sticky. Although the prevailing color is very dark gray or black, in some small, poorly defined areas there is a pronounced reddish or brownish shade. These brown or reddish-brown patches, which are recognized as approaching or even including some undifferentiated material of the San Joaquin, Redding or Madera series, are usually lighter in texture and the adobe structure is less marked. As typically developed the soil is underlain by a subsoil varying from a loam or silt loam to clay in texture and from yellow to gray in color. The subsoil is very calcareous and in places partially cemented.

The Montezuma clay adobe is not characterized by any true hardpan, but below 6 feet in a few places a substratum very similar to that of the adjoining San Joaquin or Redding soils is encountered. In places cobblestones are scattered over the surface and through the soil. Lime concretions frequently occur and here and there are abundant on the surface and in the soil. The content of organic matter is apparently high. Owing to its heavy texture and retarded drainage, this soil is very difficult to cultivate unless worked when in just the right condition, and considerable skill is required to handle it to the best advantage.

The Montezuma clay adobe is extensively developed near Planada and to the southeast as far as Le Grand. It lies just above the Madera soils and at about the same elevation as the San Joaquin. The topography is level to gently undulating, and the type is well adapted to irrigation. The lower lying bodies are sometimes differentiated from the clay adobe type of the Alamo series with difficulty. The surface drainage is generally good.

This soil produces good yields of small grains when moisture conditions are favorable, and much of it is devoted to such crops. Some of it is used for pasture. A part of the type has been divided into small holdings with the intention of growing alfalfa and fruit of various kinds. Water for irrigation is planned to be obtained by pumping.

Below are given the results of mechanical analyses of samples of the soil and subsoil of the Montezuma clay adobe:

Mechanical analyses of Montezuma clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572635	Soil	1.4	2.4	1.4	9.2	16.2	38.0	31.6
572636	Subsoil	2.0	5.7	4.2	17.4	18.7	37.0	14.8

Fresno Series.

The soils of the Fresno series range in color from brown to light brown, with variations of grayish brown and gray, the heavier, low-lying members sometimes having a dark grayish brown or dark brownish gray color as a result of the accumulation of organic matter. They are usually free from gravel and underlain, generally at depths of less than 6 feet, by light-brown to ashen-gray subsoils of fine texture and often of compact structure, the soil particles being of distinctly sharp character. A layer of white or bluish-gray, impervious, calcareous hardpan, varying in thickness from a fraction of an inch to several inches, usually separates the soil and subsoil, though in the lighter sand members the soil may extend to a depth of 6 feet without interruption. Other layers of hardpan may occur in the subsoil. The hardpan slowly softens under irrigation, but arrests underdrainage and is normally impenetrable to the roots of growing plants. The soils of this series occur as old alluvial deposits, derived from many different kinds of rocks. They occupy level to undulating and generally treeless, low, broad alluvial fans. The lighter members are frequently wind blown. The surface is sometimes rendered irregular by "hog wallows," wind-drifted ridges or remnants of older stream channels. The members of this series are not often overflowed by streams, but are frequently poorly drained and suffer from the accumulation of seepage waters and alkali salts.

Fresno sand.

The Fresno sand is typically a light-brown or brown sand, of light-grayish color on bleached surfaces, often extending to a depth of 6 feet without perceptible change in color or texture. Where the hardpan occurs at considerable depth, the soil is in places with some difficulty distinguished from the associated sand of the Madera series. It varies in different parts of the area from a pure sand to a loamy sand. Most of it, however, contains sufficient fine material to cause it to be slightly loamy when wet. It is very loose and friable, and blows under careless handling, many drifts being found to the east and south of cultivated fields. Underlying this type, usually below 6 feet, but in many places within 3 or 4 feet of the surface, are stratified, light-gray, partially cemented beds of silty material. Lime nodules and casts are occasionally found in the subsoil material. The soil is low in organic matter.

The Fresno sand is found principally in a large body in the western part of the area, south of Livingston, and east of Stevinson. To the northeast it merges imperceptibly into the Madera sand and in places the boundary between these two types is somewhat arbitrary.

The surface is level to gently undulating. In places it is rendered irregular by low dunes. The type is not subject to erosion, except along the bluffs of the Merced River. Where the water table is high undrained depressions with marsh or swamp vegetation are common.

A considerable proportion of this type is successfully irrigated. Gravity-ditch water is available over a part of the type. Pumped water can be obtained with a lift of 10 to 25 feet in many places, and this method of supplying water is increasing.

There is no alkali in the greater part of this type, but in the lower lying areas to the south and west considerable accumulations exist. In such areas salt grass is the principal vegetation in the large pastures, and attempts to grow crops have met with no satisfactory results. Where alkali is absent, however, crops do well. Most of the type was farmed to grain until the practice became unprofitable, and much of it now lies idle. Where irrigation has been developed, however, and proper cultural methods are followed, sweet potatoes, alfalfa, peaches, melons, and other crops are grown profitably. Sweet potatoes, grapes, and peaches do especially well.

The better land of this type sells in small tracts at $100 to $150 an acre.

FRESNO SANDY LOAM.

As typically developed, the Fresno sandy loam is a brown or light-brown to grayish-brown, medium-textured sandy loam, extending with little variation in the subsoil material to a depth of 3 to 6 feet or more, and underlain by the characteristic hardpan of the Fresno series. In areas of low organic-matter content the color is mainly light gray in dry cultivated or bleached surfaces. Portions of the type contain considerable silty material, and more or less mica is present in places. The quantity of organic matter present is generally low. Very few irregularities in texture and color are noticeable this type.

The Fresno sandy loam is inextensive, occurring in several small bodies in the southern part of the area and in three small bodies west of Stevinson. The topography is very similar to that of the other soils of the Fresno series. Small, shallow, poorly drained depressions occur where the hardpan approaches the surface, but these are not so pronounced as those on the Fresno loam. While surface drainage and subsurface drainage are fairly well developed, a high water table exists at present under a large part of the type.

The Fresno sandy loam is an unimportant type and little of it is used for farming. In the extreme western part of the area it is irrigated in places. Grain crops make an irregular growth, owing to

spots of alkali in the soil, but the yields are fair. Alkali salts have accumulated in injurious quantities in the surface soil throughout the type. Where the most alkali occurs the type is used for pasture. In such places bare spots are numerous and the vegetation consists almost entirely of salt grasses.

The value of the Fresno sandy loam is somewhat greater than that of the heavier types of the same series.

The results of a mechanical analysis of a sample of the soil of this type are given in the following table:

Mechanical analysis of Fresno sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572610	Soil	6.0	15.1	10.2	29.8	14.0	18.3	6.7

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam consists of a light-brown or brownish-gray to light-gray fine sandy loam extending to a depth of 2 to 6 feet without perceptible change in the subsoil material, and resting directly upon the typical Fresno hardpan, which consists of gray, cemented silty layers. The soil material is of loose structure and easy to cultivate.

It is found in comparatively small bodies in the western part of the area, forming a border on the north, west, and south for the large area of Fresno sand. One small area occurs 8 miles directly south of Merced.

As encountered in this survey the type is quite variable. The narrow body west of Livingston, bordering the flood plain of the Merced River, apparently has been formed by a reworking of the Fresno sand by the Merced River when it flowed at a higher level than at present. Most of this area is free from alkali, the hardpan is of variable depth, ranging from 30 to 80 inches, the surface is level to gently undulating and smooth, and it is well adapted to irrigation. The type has been used for grain farming, but is now being prepared for irrigation by pumping.

The areas lying south and southwest of the Fresno sand are low and wet. In these areas the hardpan is nearer the surface, drainage is very poor, and alkali salts are present in very harmful quantities. These areas are level or slightly undulating, with a smooth surface. The small area south of Merced is surrounded by Fresno loam. It is in general level and in detail hummocky. It is strongly impregnated with alkali and used mainly for pasture.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Fresno fine sandy loam:

Mechanical analyses of Fresno fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572657	Soil	0.3	7.0	8.4	30.4	27.0	21.8	5.2
572658	Subsoil	.1	6.3	8.0	30.6	28.6	21.2	5.3

FRESNO LOAM.

The Fresno loam, to a depth of 1 foot to 3 feet, consists of a brown, grayish-brown, or rather dark gray to brownish-gray, sticky loam, of good water-holding capacity. It is underlain by an impenetrable grayish hardpan from 1 inch to 12 inches or more thick. Often a gray silty layer several inches thick overlies the hardpan. The typical soil contains much silty material. The surface material sometimes has a rather bluish gray appearance. In places fine, subangular particles of quartz are scattered over the surface. The soil contains a small percentage of organic matter and has a compact structure.

In texture the soil varies somewhat, in some places approaching a fine sandy loam, as indicated in the attached analysis of a submitted sample of the soil, in other places approaching a compact silty loam or nearly a silty clay loam. Where hummocks occur the texture of the soil in the higher parts is considerably lighter than in the depressions. Along the contact of this type with soils of the Hanford series, or where sloughs have overflowed their banks, mica is often present in the soil material. The color also varies somewhat, becoming browner where the type approaches the Hanford or Madera series.

The Fresno loam occurs in several good-sized bodies in the southern part of the area. Other, smaller areas occur toward the west. It forms level, treeless plains, elevated but slightly above areas of the Fresno clay. Small hummocks and small, poorly drained depressions render the surface uneven and hinder cultivation.

The drainage of the larger bodies is better than that of the lower lying clay or silty clay loam of the same series, and is moderately good. The drainage of some of the small bodies is deficient. A few winding, sluggish streams dissect the type. On the whole, but little erosion has taken place.

Alkali salts in varying quantities have accumulated in the Fresno loam, and bare spots are of frequent occurrence. The native vegetation consists of salt grass and other plants which thrive on an alkali soil. The larger part of the type is devoted to pasture. Dry farming

to grain is practiced to a very small extent. Irrigation has not been found profitable.

The value of this soil, although greater than that of the Fresno clay, is not very high. Some comprehensive plan of reclamation must be carried out before this type will become suited to general farming.

Owing to the flooded condition of the areas of this type, which prevented the detailed survey of all parts of it, some areas of soils of the Merced and Stockton series may be included.

The following table gives the results of a mechanical analysis of a sample of the soil of the Fresno loam:

Mechanical analysis of Fresno loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572604	Soil	2.9	6.0	2.6	14.8	24.9	38.0	11.1

FRESNO SILTY CLAY LOAM.

The Fresno silty clay loam is a gray or brownish-gray to rather dark gray or dark grayish brown heavy silty clay loam, 12 to 20 inches deep, resting upon a silty clay loam or clay subsoil of the same color and containing calcareous concretions. At a depth of 24 to 54 inches this is underlain by the gray, silty hardpan of variable thickness characteristic of the Fresno series. In some of the bodies the surface soil is somewhat too dark gray in color to be typical Fresno material and probably should in part be mapped as the Merced or Stockton[1] soils, but such areas are characterized by patches having the typical light-gray color, and further differentiation was not attempted, owing to unfavorable field conditions.

The surface soil is very sticky, compact, and of smooth texture, containing a relatively high percentage of silt. The content of organic matter is usually low. The soil is very uniform throughout, only slight irregularities occurring in texture and color. In places the texture approaches that of a clay. Where hummocks and depressions occur the higher lying soil is generally a little lighter in texture than that of the depressions. This soil is subject to slight variations in color where it borders the Madera and Hanford series, becoming a little more reddish or brownish, and containing, where it joins the latter, small quantities of mica.

The Fresno silty clay loam occurs in large bodies in the southern part of the area, occupying low, level, treeless plains (Pl. I, fig. 1). Hummocks are numerous throughout the type. Often the surface

[1] The Stockton is not mapped in this survey.

is traversed by old abandoned sloughs which have caused but little erosion. A few meandering sloughs with cut banks drain the type.

Alkali is present over nearly all of the type, in many places in sufficient quantities to discourage farming, and barren spots are numerous. None of the type is under irrigation at present. Dry farming to grain is carried on to a small extent in places where the accumulation of alkali is not too great, but most of the type is used solely for pasture. Salt grass is the principal growth.

Following are given the results of mechanical analyses of samples of the soil and subsoil of the Fresno silty clay loam:

Mechanical analyses of Fresno silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572601	Soil	0.1	0.9	0.7	4.6	14.2	56.4	23.2
572602	Subsoil	.7	1.7	.9	6.0	11.9	49.7	28.9

FRESNO CLAY.

The Fresno clay is a medium-gray to rather dark gray or dark bluish gray to dark grayish brown clay of silty texture, underlain at a depth of 2 to 3½ feet by a gray, silty hardpan. The surface material over portions of the type is somewhat too dark to be typical of the series, for, as mapped, the type includes some undifferentiated material of the Stockton and Merced series, which which it merges. Typically the texture is that of a sticky, heavy, compact silty clay, which in some exposed places has an adobelike structure. Calcareous concretions occur in the subsoil, which lies just above the hardpan. The percentage of organic matter in the surface soil is usually low, except along sloughs and near the river. The hardpan, which varies from several inches to a foot or more in thickness, also varies in hardness from a compact silty layer which may soften somewhat in saturated soils to a hard, cemented layer which is but little affected by moisture. In general, the hardpan is impervious to water and impenetrable to plant roots.

The type throughout is very uniform. Where the Madera series gives way to the Fresno clay the color has been influenced slightly by the small amount of wash from the former series. Here the hardpan is neither the gray of the Fresno series nor the brown of the Madera. No distinct boundaries exist between this and adjoining types, and owing to flooded conditions at the time of the survey this part of the area could not be mapped in detail.

The Fresno clay occurs in the southwestern part of the area, near the San Joaquin River, in one large body, and in several smaller bodies east of this large area.

The topography is that of a level plain (Pl. I, fig. 1) marked by shallow, poorly drained depressions. In such places the hardpan closely approaches the surface.

As a whole the type is poorly drained. The water table is high, causing a concentration of alkali salts in the soil. A few winding, sluggish sloughs, without banks, dissect the type. Much of it is flooded periodically by the river and the sloughs.

The Fresno clay is not under cultivation at present. It represents an almost treeless plain, with a few small trees growing along the sloughs. The principal vegetation consists of salt grass and other alkali-tolerant plants. There are some barren spots, caused by the excessive accumulation of alkali salts.

The type is used entirely for pasture at the present time, and its value is low.

Following appear the results of a mechanical analysis of a sample of the soil of the Fresno clay:

Mechanical analysis of Fresno clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572617	Soil	0.1	0.6	0.4	2.6	9.3	47.4	39.6

OAKDALE SERIES.

The Oakdale series consists of light brownish gray to light grayish brown or light-brown soils, usually with somewhat heavier subsoils, and in places having a yellow or brown semicemented hardpan which occurs as intermittent or discontinuous sheets or lenses. Light-colored angular particles of quartz the size of coarse sand are found in the soil and lying on the surface where beaten out by the rains. Owing to this, a light-gray color is in places pronounced in dry-cultivated or fallow surfaces.

These soils are found in the high terraces along the Merced River. At Merced Falls, where the terrace begins, it is about 10 feet above the present flood plain of the river. The elevation increases downstream until where the main body occurs it is 30 to 40 feet, and its lower extremity about 60 feet above the river. The terrace is marked on the side nearest the river by a sharp escarpment, Hanford soils lying below the bluff. On the side farther from the stream the soils merge into the Altamont, Madera, or San Joaquin soils, which always occupy higher elevations. The soils have a typical river-terrace topography, with a level, smooth surface. They were originally covered with grass, with an occasional scrubby oak here and there. This terrace was apparently formed at the time the Fresno soils were laid down in the trough of the valley and the

Madera sands of the Merced River fan placed in their present position.

OAKDALE SAND.

The Oakdale sand is a light grayish brown or light-brown sand, 6 feet deep, in many places without distinct difference between the surface soil and the subsoil material, but with a tendency to a slightly heavier or more compact subsoil. Only occasionally is a hardpan found within 6 feet of the surface. This hardpan is a yellow or yellowish-brown, partially cemented sand, generally about a foot thick, occurring in intermittent sheets or lenses.

This soil is deficient in organic matter and is of loose, porous structure and low moisture-holding capacity, and is droughty during the dry season. It is associated with the Oakdale sandy loam, but lies at a little lower level than the latter. The topography is level to slightly undulating and drainage is excessive.

Areas of this type are found in the northern part of the county, near the Merced River.

The Oakdale sand is well suited to irrigation where water is obtainable.

In the past it has been farmed to grain but is used at present for pasture, with only an occasional crop of grain.

OAKDALE SANDY LOAM.

The Oakdale sandy loam is a light brownish gray or grayish-brown sandy loam, about 1 foot to 2 feet deep, underlain by a somewhat more compact, yellowish-gray sandy loam, extending to a depth of 6 feet. In places the texture is apparently relatively light and approaches a loamy sand. A yellow or yellowish-brown, semicemented, sandy hardpan, occurring as intermittent lenses or sheets, is found under a part of the type.

This is a light, porous, friable sandy loam and easy to cultivate. It is quite low in organic matter and is not of high moisture-holding capacity.

It is situated on a terrace of the Merced River in the northern part of the area. The general topography is level or gently sloping. The surface of part of the type is smooth; other parts are marked by scattered mounds, 3 or 4 feet high, about 30 or 40 feet across, and circular in outline. A dozen such mounds may occur in a quarter section. Drainage is good to excessive, but erosion is not a serious problem, except on the extreme edge of the bluff next to the Merced River. So far as topography and character of soil are concerned, the type is well adapted to irrigation. As yet no gravity water has been brought to this soil, but it is stated that water can be obtained at depths favorable for pumping.

There is no alkali in this soil, and it has been farmed to grain until the profits have declined on account of light yields. Part of the type is now lying idle. Some fruit orchards are being set out, but the success of this venture is doubtful.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Oakdale sandy loam are given:

Mechanical analyses of Oakdale sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572663	Soil	3.2	23.0	10.3	25.0	13.4	18.7	6.1
572664	Subsoil	2.8	22.8	10.6	26.0	11.6	17.2	8.9

HANFORD SERIES.

The soils of the Hanford series are generally of light grayish brown or buff to light-brown color. They are micaceous, smooth to the touch, friable, of porous structure, and generally free from gravel or bowlders. They are usually 6 feet or more in depth, though in places underlain by variable interstratified alluvial deposits at less than 6 feet. The soil material represents recent alluvial stream deposits, derived mainly from granitic rocks, with a relatively unimportant admixture of materials of other origin. The areas are usually elongated and parallel the stream courses. They occupy flood plains adjoining lower stream terraces and alluvial fans in valley plains. The surface is generally level to gently sloping, though sometimes marked by slight ridges or undulations or cut by sloughs or stream channels, in many places bordered by willows and other trees. Some such channels are partially filled remnants of older stream courses or are intermittent streams which carry water only in times of flood and disappear in sandy washes. The lower lying bodies or those occurring adjacent to stream courses are poorly drained and are subject to overflow where not protected by levees. The soils of this series, while occasionally carrying accumulations of alkali, are productive.

HANFORD COARSE SAND.

The Hanford coarse sand consists of 6 feet or more of brown or light-brown, very micaceous coarse sand. Often considerable fine, angular, gritty material, of the texture of very fine gravel and composed of particles of quartz and feldspar, occurs in the soil, but aside from this there is little variation. The soil is very porous, containing usually a relatively small proportion of organic matter, and water percolates freely.

The Hanford coarse sand occurs as narrow, elongated strips roughly paralleling the Chowchilla River. All of it is in the southern part of the area. The type is almost entirely surrounded by other members of the Hanford series, above which it is elevated very slightly, but sufficiently to be readily distinguishable, although it gradually merges into them.

The topography is smooth or slightly uneven. Drainage is excessive, and no alkali occurs in the soil. Owing to its small extent, coarse texture, and low mositure-retaining capacity, the type is of very little agricultural importance. At present it is all in pasture.

HANFORD SANDY LOAM.

The soil material of the Hanford sandy loam is a brown, very micaceous sandy loam, 6 feet or more in depth. It is usually of loose structure and contains a fair percentage of organic matter. The type presents some irregularities in texture, including, as mapped, variations from a moderately loose sand to a fine sandy loam. It includes narrow, elongated bodies of sand, too small to be indicated separately on the map.

The Hanford sandy loam lies mostly in the southern part of the area with a small body in the western part near Stevinson. It occurs largely along the Chowchilla River. The type merges imperceptibly with other members of the same series, by which it is generally surrounded. Where it joins the Fresno soils it gradually gives way to them and in such places for several feet the Hanford surface soil often rests on the hardpan of the Fresno series.

The topography is that of a uniformly level plain. Usually the type is well drained. No streams of importance dissect it. While alkali may occur in varying quantities in the soil, it is in places entirely free from injurious quantities.

The Hanford sandy loam is of considerable agricultural importance, where alkali is not present in harmful quantities. Some dry farming to grain is carried on, but, with irrigation, alfalfa, fruits, and vegetables give better results. The area near Stevinson is under irrigation. Areas carrying large quantities of alkali are used for pasture. The principal growth on such areas is salt grass.

The results of a mechanical analysis of a sample of the soil of the Hanford sandy loam are given in the following table:

Mechanical analysis of Hanford sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572608	Soil	6.4	19.0	11.7	26.6	12.0	20.0	4.4

HANFORD FINE SANDY LOAM.

The soil and subsoil material of the Hanford fine sandy loam to a depth of about 6 feet consists of a brown fine sandy loam, often of silty texture, containing an abundance of mica and a fair supply of organic matter. It is loose and friable in structure, has a velvety feel, and is easy to cultivate.

A large body of this type occurs in the present flood plain of the Merced River, extending from its entrance into the area at Merced Falls downstream past Livingston, where it gives way to the Hanford silt loam. The upper portion of this body very often contains some cobblestones below a depth of 3 feet, and at 5 to 8 feet it rests on a bed of coarse gravel. Farther down the river the soil is much deeper. Below this there are a few small areas on terraces about 5 to 8 feet above the present flood plain, and a larger body near Stevinson where the flood plain develops into a fan. There are some bodies also in the southern part of the area, on the alluvial fan of the Chowchilla River, and in the flood plain of the San Joaquin River.

The topography is level and the surface is smooth, except for an occasional old stream channel or strip of Riverwash. Drainage is good, except in a few places along the bluffs, where seepage from the higher lands accumulates. At times when the water is exceptionally high the Merced River overflows most of the type for periods of a few hours. In January, 1914, most of the flood plain of the Merced River was inundated, but the flood subsided within 2 or 3 hours. It had been many years since a similar flood had occurred.

The type is well situated for irrigation, and a number of small ditches supply the ranches with water from the Merced River. Where the soil is shallow, as over much of the upper part of the flood plain, considerable irrigation water is required to grow crops. In the deeper parts of the type corn and alfalfa can be grown without irrigation. It is probable that such areas are naturally subirrigated.

Alkali, carrying a considerable proportion of sodium carbonate, is found in spots in this soil. In places it is concentrated enough to prevent the growth of crops. The areas in the southern part of the survey include spots that carry much alkali and are suitable only for pasture.

This is a very valuable soil. At the very first settlement of the area the flood plain of the Merced River was selected as the place for the ranch houses, and it has therefore been under cultivation longer than any other soil in the area. Farming has been very largely confined to the production of grain and the raising of stock, only a comparatively small quantity of alfalfa and corn being grown. These latter crops, however, have done well. Near Cressey corn has produced 65 to 100 bushels per acre without irrigation. There has been

only a small development of fruit growing on the type. Many apple trees were set out at one time, but they did not do well. A few small vineyards are now in bearing, and one large fig orchard is in a thriving condition.

The following table gives the average results of mechanical analyses of samples of the soil and a single analysis of a sample of subsoil of the Hanford fine sandy loam.

Mechanical analyses of Hanford fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572643, 572661.....	Soil.....	0.4	4.4	3.8	19.7	22.2	41.9	7.4
572644.....	Subsoil.....	.5	6.0	6.6	29.6	20.0	31.0	6.6

HANFORD SILT LOAM.

The Hanford silt loam is a brown to grayish-brown silt loam containing considerable fine mica, and extending without a distinct subsoil to a depth of 6 feet. It is loose and friable in structure and fairly high in organic matter.

This type is located on the flood plains of the Merced River in the lower part of its course.

The drainage of this type is usually good, but overflows occur during exceptionally high water. It is well situated for irrigation, but the danger from overflow is great.

There is very little alkali in this soil. At present the land is generally used for the same purposes as the adjoining types in the same field, and is mainly devoted to grain or pasture. Where it is entirely free from alkali and sufficient water is available this soil produces a variety of crops.

HANFORD CLAY LOAM.

The Hanford clay loam is a brown to dark-brown clay loam, extending to a depth of 6 feet without any distinct difference between the soil and subsoil. It contains a large supply of organic matter and considerable mica. The type varies widely. Often the profile shows a section of material ranging in texture from sand to clay loam. Where the type adjoins the Fresno soils the boundaries are not distinct.

This type is confined to a few narrow, elongated bodies in the present flood plain of the San Joaquin River. The topography is generally level and smooth, being broken in places by old stream channels. Most of the type is fairly well drained, but some of it is poorly drained and has a growth of tule and water grass. It is subject to inundation during high water from the San Joaquin River, and is

liable to remain in this condition for a long time. There is apparently very little alkali in the soil. At present it is used entirely for pasture.

Madera Series.

The soils of the Madera series range in color from light to dark reddish brown. They are generally sticky when wet, readily puddled, and compact and hard when dry. They are underlain, at depths ranging from 2 to 4 feet, by reddish, ferruginous indurated clay or sandy clay hardpan, which outcrops in many places. The hardpan layer is usually fissile in character, and shows calcareous incrustations. The soil material is derived from the old Pleistocene deposits giving rise to the San Joaquin series, but subjected in the Madera series to more advanced weathering and modified by alluvial material laid down by intermittent streams. The soils occupy level or sloping to undulating, treeless plains, often containing "hog wallows," the level areas and depressions being poorly drained. While this series has generally been considered as belonging in the group of soils derived from old valley-filling material, in this survey it is more or less subject to overflow and is modified by deposition of recent alluvium.

Madera sand.

The Madera sand is a brown or light-brown to light grayish brown sand, usually without distinctive subsoil, and 6 feet or more deep. It generally contains enough fine material to give it a slightly loamy texture, but in places it is rather coarse, sometimes approaching a coarse sand which is very incoherent and drifts badly. The lower part of the 6-foot section is often yellowish brown in color. Hardpan is frequently encountered at a depth of 4 to 6 feet, but under a large proportion of the type it lies below that depth. The hardpan is light brown, medium brown, or reddish brown in color, coarse-textured, and cemented more or less thoroughly by iron. It does not occur as a continuous sheet, but is very irregular. It is not noticeably softened by water and presents an effective barrier to the percolation of water and to the penetration of plant roots.

The soil is loose in structure and very easy to cultivate. In places it is blown considerably, and along fence rows to the east and south of cultivated fields there are often large drifts of sand.

The Madera sand is an extensive and important type. It occurs in a large body around Livingston, Atwater, and Winton, south of the Merced River, and in a smaller body north of the river around Ballico. It forms the greater part of an old fan of the Merced River. There is no alkali in the soil.

The topography ranges from level to gently undulating and is marked in places by incipient dunes. Most of the type occupies low,

rounded ridges, with undrained depressions between them. Underdrainage is excessive. There are no stream channels in the type, and water passes away by percolation. The type is only fairly well adapted to irrigation, owing to its topography. Generally no attempt is made to level an entire field; the checks are made to conform to the contours and the land is leveled within each check.

The Madera sand has been grain-farmed until grain can no longer be profitably grown on it, except in years of exceptionally heavy rainfall and low winds. In dry years high winds are likely to blow out the grain, but if the seedlings are once well established and cover the ground wind will not injure the crop. Much of the soil is irrigated by gravity water taken from the Merced River. Some of it is irrigated by pumping.

This land has been very successfully developed, and peaches, grapes, sweet potatoes, alfalfa, and many truck crops are extensively grown (see Pl. I, fig. 2, and Pl. II, fig. 2).

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Madera sand:

Mechanical analyses of Madera sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572659	Soil	3.2	27.2	14.4	31.9	13.1	6.9	3.3
572660	Subsoil	2.2	24.4	14.6	33.6	12.2	7.6	5.5

MADERA SANDY LOAM.

The Madera sandy loam is a brown to light-brown sandy loam, 18 inches to 3 or 4 feet deep, of loose structure, and rather low in organic matter. The subsoil is of the same character as the soil or a little heavier in texture, and varies from reddish brown to yellowish brown in color. The soil is underlain usually at a depth of 4 to 5 feet by a brown hardpan which ranges from 6 inches to 4 feet in thickness and rests upon uncemented material of the same texture as the surface soil. The texture of the soil varies considerably, and much of the type appears in the field to be a light sandy loam or almost a loamy sand. The surface material has been redistributed and modified to some extent by winds.

The Madera sandy loam is closely associated with the Madera sand, but differs from it not only in having more fine material in the soil and subsoil, but also in having the hardpan stratum much nearer the surface. In certain areas the type approaches in topography and character the soils of the Oakdale series, and, as mapped, may include some undifferentiated Oakdale material.

This type is found in one area of considerable size north of Edendale, on the south bank of the Merced River, and in several areas lying between the fans of the Merced River and Bear Creek. In these places it is evidently a transitional soil, being a mixture of the sand of the Merced River fan with the heavy material of the Bear Creek fan. It also occurs as a rather large area reaching from Cressey eastward, and in the southeastern part of the area.

The topography is level to gently rolling, and most of the type is well drained, free from alkali, and fairly well adapted to irrigation where water is available.

In the past this soil has been used mainly for grain farming, the yields, except under irrigation, being low. At present much of it is irrigated and planted to alfalfa, fruits, and truck crops, all of which do well where properly managed (Pl. II, fig. 1). The Thompson seedless grape does especially well on it.

Below are given the average results of mechanical analyses of samples of the soil of this type and the results of a mechanical analysis of a sample of the subsoil:

Mechanical analyses of Madera sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572611, 572662.....	Soil.....	1.6	12.9	7.5	22.7	21.6	24.6	9.0
572612.....	Subsoil.....	1.8	14.6	9.6	23.4	13.6	21.2	15.6

MADERA FINE SANDY LOAM.

The Madera fine sandy loam is a light-brown or brown fine sandy loam, having a subsoil similar to the surface soil and a red to brown hardpan 3 to 5 feet below the surface.

In point of extent this is an unimportant type. It occurs in a small area south of Atwater between the Madera sand and the heavier members of the Madera series, in two areas south of Le Grand, and in one area near Burchell. The surface is level to gently undulating. In the area south of Atwater drainage is poor and alkali is found. The others are mainly free from alkali. The same crops are grown as on the adjoining sand and sandy loam.

MADERA LOAM.

The Madera loam, to a depth of 4 to 6 feet or more, is a brown loam of loose, friable structure, with no distinct subsoil. It is in places of relatively silty texture, closely approaching the standards of a silt loam, and there may be small included areas of true silt loam tex-

ture. In places this type is underlain, at a depth of 4 to 6 feet, by the typical red or reddish-brown Madera hardpan, but this usually is not found nearer the surface than 6 feet.

The Madera loam is rather extensively developed around Le Grand in the fan of Mariposa Creek. It also occurs as a narrow terrace along Dry Creek and as natural levees adjacent to the courses of Bear Creek and some of the smaller streams. The topography is level or gently sloping, and the soil is well drained and well adapted to irrigation. No alkali was noted in any part of this type. It is easy to cultivate and has a fair supply of organic matter.

The Madera loam was originally covered with grass, with a scattering growth of oak. It is at present highly prized for alfalfa, truck, and fruit crops, although much of it is still used for grain growing (Pl. IV, fig. 2). The yields of all crops are satisfactory. On the whole, it is one of the best types in the area.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Madera loam:

Mechanical analyses of Madera loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572633	Soil	0.2	0.6	1.2	17.6	29.2	39.0	12.3
572634	Subsoil	.0	1.1	2.6	22.4	29.5	32.7	11.8

MADERA SILT LOAM.

The Madera silt loam is a brown to reddish-brown silt loam from 2 to 3 feet deep. It is somewhat variable in texture, the silt content in some places being rather low. In others the soil is heavier, approaching a clay loam in texture. The soil is compact when dry, but under favorable moisture conditions it can be worked with moderate ease into an excellent seed bed. The subsoil is similar to the soil in texture, but usually has a yellowish-brown color. A brown or reddish-brown hardpan underlies the subsoil, usually at a depth of 3 to 5 feet, but under about one-third of the type it occurs below 6 feet.

The Madera silt loam is by far the most extensive type, and it is also one of the most valuable, in the county. It forms most of the large fan bordering Bear Creek and its distributaries on the floor of the valley and a large part of the fan of Mariposa Creek. It is developed as a terrace along Bear Creek, where it emerges from the foothills. In the fan of Mariposa Creek it lies farther out from the foothills than it does in the Bear Creek fan. It is also found along Dry Creek and some other small streams. This type is bordered by

the Madera loam on the side nearest the streams in many places. On the lower edge it usually adjoins the Fresno soils. Within the area of the silt loam are some depressions containing heavier members of the Madera series, but these, on account of their small size, were not separated on the map.

The topography is smooth, with a gentle slope, 5 to 10 feet to the mile, toward the trough of the valley. In places there are a few low mounds resembling, though less prominent, those found in the San Joaquin soils. There are also a few shallow, abandoned stream channels. As a whole, the type is well suited to irrigation. It is not subject to erosion. Drainage is generally good, being inadequate only in some of the lowest places. Where the type borders the Fresno soils there are some spots containing alkali.

This soil was formerly used principally for grain farming and it is still largely used for that purpose. Grain yields under dry-farming methods were formerly heavy, but they have decreased to a point where the production of such crops is unprofitable except in very favorable years, the ordinary yield of barley being now less than 10 sacks per acre.

At present much of the type is under irrigation and it is considered a good general-purpose soil. Where irrigated it is in a high state of cultivation and produces good yields of alfalfa, figs, almonds, pears, olives, and late truck crops.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Madera silt loam are given.

Mechanical analyses of Madera silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572626	Soil	0.3	0.8	0.8	9.9	23.5	49.7	14.9
572627	Subsoil	.2	.6	.7	10.0	28.0	41.7	18.8

MADERA CLAY.

The Madera clay is a dark-brown to reddish-brown clay or silty clay varying considerably in texture within short distances. On the slight elevations the soil is light in texture and in the depressions it is very heavy. The subsoil differs from the soil only in color, often being yellowish brown. The typical Madera hardpan occurs at depths of 3 to 6 feet.

The soil has a fair content of organic matter. It is compact and very difficult to handle, especially when not worked under proper moisture conditions.

The largest two areas of this type occur near Merced, one north and one south of Bear Creek, lying a short distance back from the stream. the soil along the stream being the Madera silt loam. A few smaller areas are scattered through the Bear Creek fan, occupying slight depressions surrounded or bordered by lighter members of the Madera series.

This type forms a broad, level plain, in places covered by low, flat hummocks and occasionally cut by shallow, deserted stream channels. Surface drainage is usually fair, but water enters and passes through the soil slowly. Southwest of Merced the type is poorly drained and puddled in places. Where drainage is established the soil is well adapted to irrigation and much of it has been ditched.

Some alkali spots occur, but most of the type is free from harmful quantities of soluble salts. Much of it is still used for grain farming, and with normal rainfall good yields of grain are obtained. Under irrigation alfalfa does fairly well. Fruit growing is extending to some parts of this soil, the most important plantings being figs.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Madera clay:

Mechanical analyses of Madera clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572620	Soil	0.0	0.2	0.2	3.4	16.5	45.9	33.6
572621	Subsoil	.2	.7	.6	4.2	11.6	48.3	31.6

MADERA CLAY ADOBE.

The Madera clay adobe is a dark grayish brown or brown clay with a pronounced adobe structure and 18 inches to 2 feet deep. This is underlain by a dark grayish brown clay of very compact structure. The typical Madera hardpan is encountered at depths of 3 to 5 feet.

This is a minor type; only a few small areas are mapped. These are scattered over the Bear Creek fan and are surrounded for the most part by the other members of the Madera series. The type occurs also in a few areas too small to map. It occupies small depressions, 12 to 18 inches below the surrounding soils. The surface is level and smooth and the drainage poor.

The areas of this type are so small that no special crop system is applied to them, and they are used for the same crops as the Madera clay.

The results of mechanical analyses of samples of the soil and subsoil of the Madera clay adobe follow:

Mechanical analyses of Madera clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572618	Soil	0.0	0.4	0.4	4.6	13.0	40.9	40.6
572619	Subsoil	.0	.4	.4	4.0	14.6	48.0	32.7

HONCUT SERIES.

The Honcut soils are of light reddish brown or brown color and are underlain by brown or reddish-brown subsoils. Waterworn gravel is sometimes present in the vicinity of stream courses, but is not of general occurrence. The surface is slightly sloping and drainage is fairly well established. These soils are of alluvial origin, and occupy stream bottoms and recent flood plains or lower terraces and small alluvial fans.

HONCUT FINE SANDY LOAM.

The Honcut fine sandy loam is a brown or reddish-brown to light-brown fine sandy loam, from 2 to 3 feet deep, having a loose structure and a fair content of organic matter. The texture is subject to some variation, ranging in places to a medium sandy loam. There is very little difference between the soil and subsoil, except that the latter is generally more variable in texture, and in places grades downward into a gravelly loam.

This is an inextensive type. It is found only on the flood plain of Dry Creek, in the northern part of the area. It is level and smooth, well drained, and well suited to irrigation where water is obtainable. At present it is nearly all in grain, of which the yields are satisfactory. It is a valuable soil, but of minor importance, owing to its small extent.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the Honcut fine sandy loam are given:

Mechanical analyses of Honcut fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572647	Soil	1.6	8.0	5.9	24.3	17.4	27.1	15.6
572648	Subsoil	4.2	17.2	10.2	30.2	11.0	15.4	12.1

Merced Series.

The soils of the Merced series are of dark-brown to dark-gray or drab color, with light-brown, gray, or drab subsoils, usually calcareous. Both soil and subsoil are in places somewhat micaceous. The series is of alluvial origin. It occupies river flood plains and lower terraces, usually of flat surface. The soils are frequently poorly drained and subject to overflow during times of high water and often contain injurious quantities of alkali salts. Sloughs and remnants of former stream channels are of frequent occurrence.

Merced silty clay loam.

The soil of the Merced silty clay loam is typically a dark-gray or drab to black, smooth silty clay loam, with a high content of organic matter. It is generally noticeably micaceous, but less so than the soils of the Hanford series. The subsoil is dark gray, slaty gray, or drab, of rather compact structure, and generally similar to or heavier than the surface soil in texture. It may, however, rest upon a deeper subsoil of brownish-colored alluvial deposits or may include thin seams or lenses of fine sandy material. Fragments of partially decayed plant stems and small, irregular calcareous nodules or concretions are of frequent occurrence in the subsoil material, and may be accompanied by thin, soft, calcareous seams or crusts or by a soft, calcareous, hardpanlike material.

As mapped, there is considerable variation in the texture of the surface soil, and the type probably includes some undifferentiated material of lighter or heavier types of the Merced series, as well as some material of the Fresno and Hanford series. Much of the area mapped as this soil was not accessible at the time of the survey, on account of its flooded condition, and could not be mapped in detail.

The Merced silty clay loam occupies the lower lying, basinlike flats adjoining the San Joaquin River, and is marked by sloughs or remnants of stream channels or by swampy depressions, often containing water, with a growth of water grass and tule. Drainage is poorly established. The type is generally inundated by the San Joaquin River for periods of several weeks or months annually. Even when not submerged it is characterized by a high water table. The content of alkali salts, however, is usually lower than in the adjacent and slightly higher lying soils of the Fresno series, and the hardpan is patchy and permeable.

The soil material is of compact structure, has a tendency to become puddled when wet, and bakes and checks upon drying. Under favorable conditions of drainage, moisture content, and cultivation, however, it could be maintained in a friable condition. The type is devoted entirely to pasture.

Elder Series.

The soils of the Elder series are dark gray and friable and often carry quantities of dark-colored waterworn gravel. The subsoils are subject to considerable variation, but are usually of light texture, stratified, porous, and often gravelly. The soils represent recent alluvial material derived from metamorphic rocks occupying stream flood plains and lower terraces traversing semiarid valleys. They are often subject to overflow, and in many places forested with oak, willow, and brush. The surface is level to slightly ridged or eroded, and is frequently marked by sloughs or stream channels. The soils are often of low moisture-holding capacity and subject to drought. As mapped in this survey small areas of other series are included.

ELDER SILT LOAM.

The Elder silt loam is a gray to dark-gray silt loam, 2 to 3 feet deep, underlain by a subsoil of the same texture but a little lighter in color. Occasionally thin beds of gravel are found in the soil and subsoil, especially at lower depths. There is a fair proportion of organic matter in the soil, and it is very friable and easy to cultivate. Some areas of brown soils (Honcut series) are included.

Several small bodies of this type are found in the eastern part of the area bordering intermittent streams which issue from the foothills. These bodies are level, well drained, and well suited to irrigation if water is made available. They are subject to inundation for only a few hours during periods of heavy rainfall. With the exception of small spots where black alkali occurs, this is a very valuable type. It is used mainly for grain crops and yields are very satisfactory.

ELDER SILTY CLAY LOAM.

The Elder silty clay loam is a dark gray, brownish-gray, or drab silty clay loam, sometimes of rather low silt content and approaching a clay loam, underlain at about 3 feet by a subsoil of the same texture but slightly lighter in color. Occasionally small quantities of gravel are found in the soil and subsoil, especially in the lower depths. There is a fair proportion of organic matter in the soil and it is easy to cultivate. Some areas of Honcut soils are also included with this type.

This type occurs in several narrow bodies in the eastern part of the area, bordering Miles and upper Dry creeks. The type is level, well drained, and well suited to irrigation if water can be obtained. During periods of heavy rainfall it is subject to overflows of a few hours' duration. It is used for pasture and grain crops, and yields are very satisfactory. It is a very valuable soil, but occurs in such small areas that its actual importance is not very great.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Elder silty clay loam:

Mechanical analyses of Elder silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
572639	Soil	0.6	2.2	1.8	10.4	14.0	51.2	19.8
572640	Subsoil	3.0	8.0	5.2	19.2	18.4	27.8	18.6

ELDER CLAY.

The Elder clay is a dark-gray or drab clay, compact and occasionally adobelike in structure, and extending to a depth of 6 feet or more with no distinct subsoil. The soil becomes sticky when wet and is easily puddled, and bakes and checks upon drying. It is difficult to work, but under favorable conditions can be maintained in good tilth.

The Elder clay is limited in occurrence to small bodies in the eastern part of the area, bordering small streams. The drainage is fair to poor. At present the type is used mainly for pasture, but a small part is in grain.

MISCELLANEOUS MATERIAL.

DUNESAND.

The Dunesand as mapped in this area is a light-gray sand which has been entirely reworked by wind, resulting in its present topographic condition of pronounced dunes with occasional "blowouts" and undrained depressions between the wind-formed ridges. The material from which the dunes are formed is the Fresno sand.

Dunesand occurs in two small bodies in the western part of the area along the southern boundary of the large body of Fresno sand. It contains no alkali, and is covered with a sparse growth of grass. It is nonagricultural and is used entirely for pasture.

RIVERWASH.

Riverwash comprises material of very coarse texture, consisting of waterworn gravel, cobblestones, coarse sand, and finer sediments in varying quantities. The coarse material usually predominates, making the type leachy and incoherent in structure.

This type occupies low-lying, flood-swept areas, strips or islands along the Merced River, and old channels throughout its flood plain. It is encountered also along the channel of the Chowchilla River.

The type has an uneven, scored or pitted surface and is subject to erosion and reworking at frequent intervals. The water table often lies near the surface. In places which have not recently been disturbed cottonwood and willow make a rapid growth. Otherwise the type is barren in appearance. Riverwash is entirely alluvial in origin, most of its material of coarser texture being rolled along stream courses into position during floods. It is very inextensive and is used for pastures and for the production of firewood.

ROUGH STONY LAND.

Rough stony land is a nonagricultural type embracing areas having a broken, deeply dissected, precipitous, and predominantly rocky surface. The soil material varies with the character of the rock in different places.

The bodies of Rough stony land in the Merced area occur along its eastern border, being associated with the edge of the foothill belt. In the northern part of the county there is an area which consists of outcroppings of igneous rocks belonging geologically to the Bedrock series. The small quantity of soil material found among the rocks belongs to the Aiken soils. Very few trees are found in this body.

From Merced Falls southeastward along the edge of the foothills to the eastern point of the area are small, scattered buttes of the Tejon formation of rocks. These buttes consist of horizontal brown sandstones with an elevation of 50 to 100 feet above the surrounding plains. Their tops are bare rocks, in places very irregular, and their sides are talus slopes which merge with the Mariposa soils. They are generally covered with a growth of live oak and small, shrubby bushes, and present a strong contrast to the adjacent plains, which are treeless.

These areas of Rough stony land are characterized by excessive drainage, which removes the soil material almost as fast as it is formed. They are valuable only for grazing and for the small quantity of timber produced.

TAILINGS.

Tailings consists of the debris of the gold dredges working at the present time or recently in the bed and lower terraces of the Merced River. It is confined to one small body near Snelling. The material is composed mainly of the upturned and reworked gravel and sand of the Riverwash and shallow soil found there, but it is of much less value than the original soil, for what fine material existed there originally is now at the bottom of the heap or has been sluiced away and the coarsest cobbles are on the surface. Some of the adjoining and more valuable areas of the Hanford fine sandy loam have been encroached upon.

The surface is very uneven, with ridges and mounds of gravel 5 to 15 feet high. The material is nonagricultural.

IRRIGATION.

About half the land in the present survey is suitable for irrigation. The principal irrigation system in the area is that of the Crocker-Hoffman Land & Water Company, which, with its main ditch and laterals, supplied water in 1912 to 19,500 acres of land lying near the central part of the survey. The water is taken from the Merced River a few miles below the point at which it enters the county. The canal flows nearly parallel to the Merced River for about 10 miles and then turns south, the water being distributed over the plains from Livingston to and beyond Merced. This company has water rights to only a part of the water of the river, there being a number of small ditches that have prior rights, and it is necessary that a large proportion of the water flow over the dam at all times. Under present conditions, the company has reached the limit of land which it can irrigate in years when the flow of the river is low. There are about 170,000 acres of good land which is so situated that it could be irrigated from the present canal system with an additional water supply.

In connection with extensive irrigation in this part of the area it has been proposed to build a storage reservoir for flood waters in the upper valley of Dry Creek, in the northern part of the area, and the site has been carefully surveyed. A dam 90 feet high would produce a reservoir flooding 11 square miles of land and would impound 327,000 acre-feet of water, which would be obtained from the flood waters of the Merced River, and 230,000 acre-feet of the water in the reservoir could be drawn off directly into the existing canal system. This would make it possible to irrigate much more land, and it seems probable that this plan will be carried into execution. The average annual flow of the Merced River is reported to be 1,228,000 acre-feet, which is ample for all the irrigable land in the area, if the water can be saved and used.

The "east-side" canal, which supplies the Stevinson colony lands in the west-central part of the survey, taking its water from the San Joaquin River, watered 11,500 acres in 1912. Much of the land which it serves is spotted with alkali, and the results from the irrigation are more or less disappointing. There has been much litigation over water rights in the San Joaquin River and the matter is not yet settled.

There are several small ditches taking water from the Merced River to irrigate the bottom lands, about 2,000 acres being thus watered.

In 1912, 4,680 acres in Merced County were irrigated from pumping plants. The area thus irrigated is rapidly increasing, and it seems capable of much greater extension. Flowing wells are found in the trough of the valley, but most of the land adjoining them is impregnated with alkali, and its irrigation is not attempted. Over most, if not all, of the area, where the soil is suitable for irrigation, water may be obtained by pumping. In many places water rises to within 10 to 25 feet of the surface. This is true in the country between Livingston and Atwater and in that around Planada and Le Grand. So far this method has given great satisfaction. Electrically driven pumps are mainly used in lifting the water, although some gasoline engines are employed. The San Joaquin Light & Power Company, besides supplying lights for the towns in the area, is extending lines to the farms and supplying power. Near Le Grand, where there is no gravity system of irrigation, over 40 electric power pumps have recently been put into operation. One advantage in an individual irrigation system is that the land is not subject to increase in weeds through introduction of seed carried by the water as is the case with the gravity system. Johnson grass is quite a nuisance in some parts of the area.

A few wells have been sunk on the Oakdale soils and the Madera sand north of the Merced River. The depths of these range from 200 to 300 feet, and the water is said to rise to within 40 to 80 feet of the surface. In this area the check method of applying the water is the principal one used for alfalfa. For trees, vegetables, vines, and berries the ditch or furrow method is used.

ALKALI.

The term "alkali" is commonly applied to any soluble mineral salt which has accumulated in the soil in sufficient quantities to be detrimental to plant growth. Such salts usually leave an incrustation at the surface when moist soil is exposed to the air and allowed to become dry. If this incrustation is uniformly white, the term white alkali is applied to it, but if it stains water or wet soil brown or black it is called black alkali. The alkali salts in this area consist mainly of sodium, magnesium, and calcium chlorides, bicarbonates, and sulphates. These are all white. When, in addition to these, sodium carbonate is present in conspicuous quantities it forms the black alkali. The sodium carbonate produces the black or brown color by its corrosive action on organic matter.

Alkali is produced primarily with the weathering of the rocks which have produced the soil. In humid regions the soluble materials are leached out and carried away by the ground water, but in

semiarid regions, such as this area, they are not completely dissolved and removed, or may be only carried into the valleys or lower lying lands. If drainage is restricted and the underground water lies within such distance of the surface as to make capillarity effective, a continual evaporation results in their accumulation upon the surface in injurious quantities. In this area the presence of alkali is indicated by bare, smooth spots on which grass does not grow and in which the soils run together and bake when cultivated, by the black appearance of surface water and incrustations around water holes, by the growth of alkali weeds and salt grass, and by white incrustations on the surface when the ground becomes thoroughly dry.

In many cases the alkali content is much lower than the surface appearance would lead one to believe. This is because much of the soil has a high capillary power, which permits the free movement of the soil moisture and the concentration of most of the alkali at the surface.

The injury caused by alkali salts varies somewhat with the texture of the soil. In soils of light texture the same percentage of alkali will do more harm than in those of heavy texture. In some of the sand in this area the alkali accumulates in the surface soil in quantities sufficient materially to injure crops, yet during the rainy season, when it is distributed through several feet of soil, less than 200 parts per 100,000 is found in the surface foot of soil.

Alkali salts have accumulated in some areas of the soils of the southern, southwestern, and western parts of the Merced area. The land lying in and near the trough of the valley, except that immediately along the San Joaquin River and sloughs where it has been subjected to inundation, is more or less affected with alkali. This strip roughly parallels the San Joaquin River, varying in width from 5 to 12 miles. In addition to this general body of alkali soils there are small spots of alkali in the soils of the Merced River bottoms and along Mariposa Creek. These spots contain a large proportion of black alkali. The large body of alkali soils previously referred to also contains more or less black alkali.

In the Merced area a separation of the alkali-affected areas is made on the soil map, depending upon the injurious nature of the alkali, into areas in which alkali is present and those in which it is present in spots. Those areas in which alkali spots have made their appearance but have rendered worthless approximately less than 20 per cent of the soil, and where farming can still be carried on with profit, are designated as the spotted areas. In this class bare spots 6 to 12 feet in diameter where a high concentration of salts exists are numerous. These spots are not only troublesome in themselves, but they indicate

a general tendency toward accumulation of more excessive quantities of alkali, which may be increased by careless irrigation and improper management of the soil.

In the areas designated as containing the more uniform and constant quantities of salts the accumulations seem to be continuous. The concentration varies, some land being uniformly affected but producing a good growth of salt grass, while other areas produce nothing but a very sparse growth of the most alkali-resistant plants, in some cases having 2 per cent, or 2,000 parts in 100,000, of salts in the surface foot. Barren spots frequently occupy 5 to 10 per cent of the surface. Where the surface is hummocky the spots are usually on the sides of the hummocks.

In the Merced area the soils affected in part by alkali are those of the Fresno, Hanford, Merced, and Madera series. That portion of the Fresno sand in which the water table is high contains an injurious quantity of alkali, although the actual percentage is not very high. The Hanford soils are most affected in the southern part of the area. Several alkali spots in the Hanford soils have made their appearance along the Merced River. But little of the Madera series is affected by alkali, which occurs only where these soils border the Fresno and approach the trough of the valley. The soils of the Merced series frequently carry some alkali, but usually in lower concentrations than occur in the adjoining Fresno soils.

The chief growth on the soils affected by alkali in this area is salt grass. Approximately one-fourth of the area surveyed is affected by alkali. Of this a large part can not be used for agriculture, except for pasture, until reclaimed. Only on the part in which the occurrence of alkali is limited to spots can crops be grown with profit. This part is largely dry farmed to grain.

The effective reclamation of alkali lands under the conditions occuring in this area is a problem that has not been entirely mastered as yet, but there is hope that it can be accomplished by repeated flooding and draining of the areas affected. Certainly the control of the ground water is essential in the reclamation of alkali land. So long as the ground water remains within 3 to 5 feet of the surface during a large part of the year there is danger of surface accumulation. When local spots occur and the ground water is not near the surface, as is often the case, the condition may be improved temporarily by thorough cultivation and addition of manure. When irrigated these spots should be flooded thoroughly to drive the alkali down, and the surface cultivated as soon afterward as possible to prevent the return of the alkali. By these means a crop usually may be grown on the spots, but as soon as vigilance is relaxed the alkali returns to the surface.

SUMMARY.

The Merced area comprises about half of Merced County. It lies east of the San Joaquin River, and covers about 960 square miles, or 614,400 acres. Its topography ranges from that of the foothills proper to flat, as in the trough of the valley.

Permanent settlement of this region began in 1849, and Merced County was established in 1855. The town of Merced was made the county seat in 1872, soon after the Southern Pacific Railroad was extended through the area. Good transportation facilities are afforded by the Southern Pacific and the Atchinson, Topeka & Santa Fe Railroads.

The area has the characteristic climate of the San Joaquin Valley, embracing a cool, rainy season during the winter months and a hot, dry season during the summer. The climate is well suited to dry farming, and where water is available a wide range of crops may be grown under irrigation.

The first settlers gave most of their attention to stock raising, which is still an important industry. Grain was produced from the first and gained in importance until the time of the great bonanza grain fields, which reached their highest development about 1890. Since that time wheat growing has declined and barley has largely taken its place. The year 1890 marked the beginning of irrigation in the area on a large scale. The tendency now is toward smaller land holdings, with more intensive crop production, although about half the area is apparently best suited to pasture. While grain farming is still extensively followed, it is steadily giving way to the production of alfalfa, fruits, and sweet potatoes under irrigation.

The soils of the area fall naturally into four groups, (1) residual soils, (2) soils derived from old valley-filling material, (3) soils derived from recent alluvium and later valley-filling material, and (4) miscellaneous material.

In the first group are the Aiken series, including red soils from basic metamorphic eruptive rocks; the Mariposa series, including brownish-yellow or pale-yellow soils from the Mariposa slates, and the Altamont series, including light grayish brown to brown soils from sandstones and soft shales, sands, and clays.

The second class, or soils derived from old valley-filling material, consists of the Redding series, including red soils occupying the highest part of this deposit and having a hardpan and gravelly substratum; the San Joaquin series, also red and with hardpan, but without gravel; the Alamo series, including dark-gray to black soils with a red hardpan; the Montezuma soils, of the same color, but with calcareous subsoils and without a hardpan; the Fresno series, including brown to gray soils with a gray hardpan occurring in the basin of

the valley; and the Oakdale series, including brown to gray soils found as a high river terrace on the Merced River.

The third class, or soils derived from recent alluvium and late valley-filling material, embraces the Hanford soils, which are brown, micaceous soils derived mainly from granitic rocks; the Madera series, consisting of brown soils, usually with a hardpan; the Honcut series, consisting of brown soils derived from a variety of rocks; the Merced series, including dark-gray to black soils found on the flood plains of the San Joaquin River, and the Elder soils, which are gray to drab in color and derived from metamorphic sedimentary rocks.

The fourth group of soils, consisting of miscellaneous material, is represented by four types or classes of material. These are Dune-sand, Riverwash, Rough stony land, and Tailings.

In all there are, representing these groups of soils, 14 series and 47 soil types, exclusive of the miscellaneous material.

A large part of the land is irrigated. One large system is irrigating about 20,000 acres in the central part of the area at the present time. Another system is irrigating 11,500 acres in the western part of the area. There are several small canals used by farmers along the Merced River. Irrigation by pumping from wells is growing in importance.

In parts of the area, mainly in and near the trough of the valley, alkali occurs in sufficient quantities to be a serious hindrance to agriculture.

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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SOIL MAP
CALIFORNIA
MERCED SHEET
U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY
UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
THOMAS F. HUNT, DIRECTOR
CHARLES F. SHAW, IN CHARGE SOIL SURVEY
SOIL PROFILE
(6 feet deep)
LEGEND
CONVENTIONAL SIGNS
R. 10 E.
R. 11 E.
R. 12 E.
R. 13 E.
R. 14 E.
R. 15 E.
R. 16 E.
R. 17 E.
MERCED
Snelling
Merced Falls
Livingston
Atwater
Planada
Le Grand
Macy H. Lapham, Inspector Western Division.
Soils surveyed by E. B. Watson, E. C. Eckman, and L. C. Holmes
of the U.S. Department of Agriculture and J. W. Nelson,
J. E. Guernsey, and C. J. Zinn of the University of California.
Scale 1 inch = 1 mile
SNYDER & BLACK, N.Y.
Field Operations
Bureau of Soils
1914